Organisation pour la Mise en Valeur
du Fleuve Sénégal
(O. M. V. S.)

ASSESSMENT OF ENVIRONMENTAL EFFECTS OF PROPOSED DEVELOPMENTS IN THE SENEGAL RIVER BASIN

PLAN OF ACTION

FINAL REPORT

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In association with

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PLAN OF ACTION

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CHAPTER I

INTRODUCTION

Throughout a large portion of the Senegal River Basin, the lack of water and its uneven distribution has been an obstacle to the establishment of a desirable quality of life for the inhabitants. These factors have also deterred economic growth and stability. The Senegal River Basin's resources, in their present stage of development are only marginally able to support basic human needs. This deficiency has been especially critical during recent periods of adverse weather when drought conditions have prevailed over an extended period of time.

The Organisation pour la Mise en Valeur du Fleuve Senegal

To deal with these problems, the Organisation pour la Mise en Valeur du Fleuve Senegal (O.M.V.S.) was created on March 11, 1972 by its Member States, Mali, Mauritania and Senegal. As an intergovernmental agency, it has the responsibility for the conceptualization, coordination and execution of projects to develop and use the resources of the Senegal River Basin within the boundaries of the three Member States. Under the theory of international law known as "equitable utilization", adopted by the three riparian states, the O.M.V.S. has a degree of autonomy to react unilaterally to new information. Internal resolutions adopted by the O.M.V.S. Council of Ministers are binding on the Member States.

Through a concerted and integrated action, the Member States of O.M.V.S. intend to upgrade the quality of life for the populations of the River Basin. This goal is to be achieved through the harmonious coordination of local, regional, national and international development projects to meet the following objectives:

- To provide and improve income for the maximum number of inhabitants in the Basin and neighboring regions;

To establish a more stable balance between man and his environment, not only within the Basin, but throughout the three Member States;

- To render the economies of the three Member States less vulnerable to climatic and external factors;

- To accelerate the economic development of the three Member States and to assure interstate cooperation.

The O.M.V.S. Development Program

The current planning by the O.M.V.S. calls for an integrated development scheme comprised of constructing or providing administrative and technical support for the following:

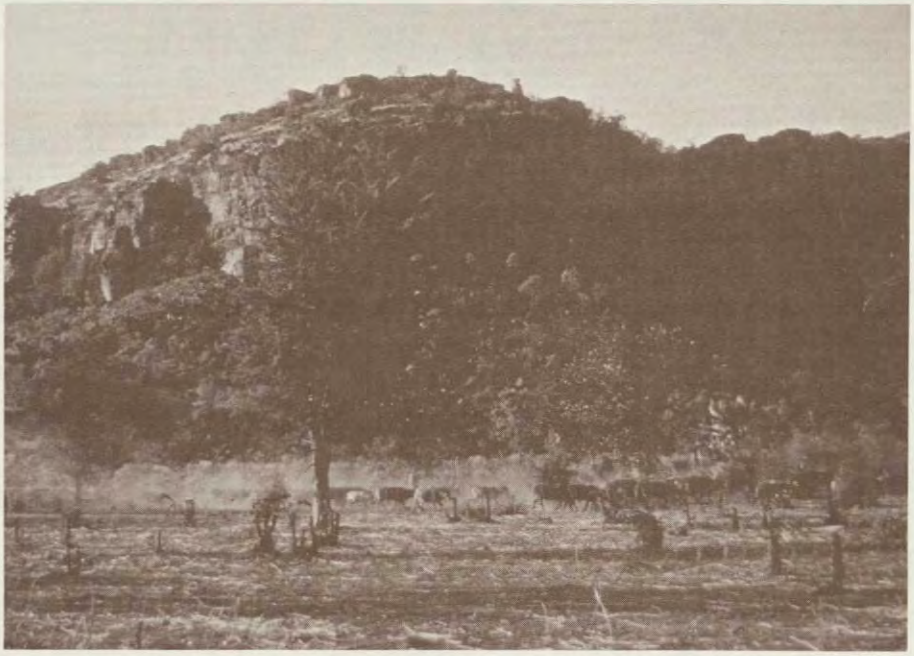
- Dams near Manantali and Diama

- River navigation system

- Agricultural perimeters

- Industrial installations

In come cases, the O.M.V.S. will serve as the implementing agency for a program. In other cases, it will serve as a catalyst for initiating and supporting development programs to be undertaken by governmental agencies of the Member States or private entities.



Herding cattle past one of the buttresses of the proposed Manantali Dam. Such land use conflicts are a major reason integrated land use planning is needed in the Senegal River Basin.

The Manantali dam is to be constructed approximately 1200 kilometers upstream from St.-Louis, Senegal. It will be located on the Bafing River, which is a major tributary of the Senegal River. The water stored in the dam's reservoir will be used to augment low river flow, thereby permitting year round navigation between St.-Louis, Senegal, and Kayes, Mali, and irrigation of agricultural perimeter areas. Reservoir water will also be used to generate electricity for domestic and industrial use. The Diama dam will be constructed approximately 27 kilometers upstream from St.-Louis and will serve as a barrier to saltwater encroachment into the River Basin during periods of low river flow. Water stored in the Diama reservoir will facilitate navigation and be used for irrigation, municipal, and industrial purposes. Navigational locks will be provided in the dam to permit movement of river vessels between the estuary and the main stem of the Senegal River. The deep water port at St.-Louis will provide facilities for transhipping

products of the River Basin to worldwide markets. The irrigated perimeter projects, which will be adjacent to the River, will permit year-round farming of a total of 255,000 hectares of land that is presently subjected to intermittent flooding and drought. It is hoped that the agricultural products to be obtained from these irrigated areas will contribute significantly toward eliminating the present cereal and livestock production deficits. Additionally, the irrigated perimeters will produce raw materials needed in operating such agro-industries as sugar mills and food processing plants. Electric power generated by water stored in the Manantali reservoir and its subsequent distribution together with development of an effective year-round navigation system will enhance the technical and economic feasibility of mineral resources development in the upper basin.

Impetus for the Environmental Assessment

In July 1974 at the prospective donors meeting held by O.M.V.S. in Nouakchott, Mauritania, the United States Agency for International Development (USAID) proposed that a detailed evaluation be undertaken to determine the potential effects of the integrated development plan on the environment of the River Basin and its population. USAID felt that a balanced approach between the considerations of economic development and the protection of the environment must be considered by all potential donors to insure that maximum long range benefits would be derived from the O.M.V.S. development program. The early identification of adverse impacts would permit the application of corrective measures prior to the development of environmental damage. Likewise, avoidance of irreversible damage to national, human and natural resources would be a prime objective. USAID noted that such a study would comply with Title 40 of the National Environmental Policy Act of 1969 of the United States, permitting U.S. government participation in the O.M.V.S. development program. This proposal was supported by other prospective donors, as well as O.M.V.S., who were anxious to avoid problems that have arisen in similar water resource projects in tropical and sub-tropical areas of the world.


LEGENDE
LIMITE DU BASSIN
BASIN BOUNDARY
FRONTIERE
INTERCOUNTRY BOUNDARY
ROUTE GOUDRONNEE
MAIN ROAD
COURS D'EAU
STREAMS
CAPITALES
CAPITALS
VILLES
TOWNS
PARC NATIONAL DE DJOUDJ
DJOUDJ PARK
SITES DES BARRAGES
DAM SITES
NOUAKCHOTT
Aleg
Kiffa
Kaedi
Podor
Rosso
Dagana
Richard Toll
DIAMA
St-Louis
Louga
Matam
Bakel
Nioro du Sahel
Nara
DAKAR
Thies
Mbaké
Diourbel
Mbour
Kidira
Kayes
Kaolack
Kaffrine
Tambacounda
BANJUL
Brikama
Velingara
Kolda
Bignona
Ziguinchor
Oussouye
Cap Skiring
MANANTALI
Kita
BAMAKO
Kédougou
MAURITANIE
SENEGAL
GAMBIA
MALI
GUINÉE BISSAU
GUINÉE
OCEAN ATLANTIQUE
AFRIQUE
CARTE LOCATIVE
LOCATION MAP
REGION
DELTA
SAINT-LOUIS à DAGANA
DELTA
MOYENNE VALLEE
DAGANA à BAKEL
MIDDLE VALLEY
HAUTE VALLEE
AMONT DE BAKEL
ABOVE BAKEL
UPPER VALLEY
BASSIN DU FLEUVE SENEGAL
SENEGAL RIVER BASIN

Objectives of the Environmental Assessment

A grant agreement for the proposed environmental assessment was signed between USAID and O.M.V.S. on February 25, 1976. The objectives of the study were:

- To evaluate the interrelated effects on the environment caused by development in the Senegal River Basin;

- To optimize the long-term benefits by insuring that environmental and social factors have been identified and included in the cost-benefit analysis of individual projects;

- To provide the O.M.V.S. riparian states with a plan of action for formulating programs and projects that mitigate adverse environmental effects and capitalize on those deemed beneficial.

The following chapters of this report have been developed in response to these objectives.

CHAPTER II

PRINCIPAL FINDINGS AND CONCLUSIONS OF THE ENVIRONMENTAL ASSESSMENT

A basic frame of reference for the environmental assessment, as shown in Figure 2, is fundamental to an understanding of the recommendations given in the final chapter of this Plan of Action report.

It is first necessary to view the interaction of the proposed O.M.V.S. development program with the hydrologic system and to determine which conditions will change and which will remain unchanged. These changes to the system components, which are:

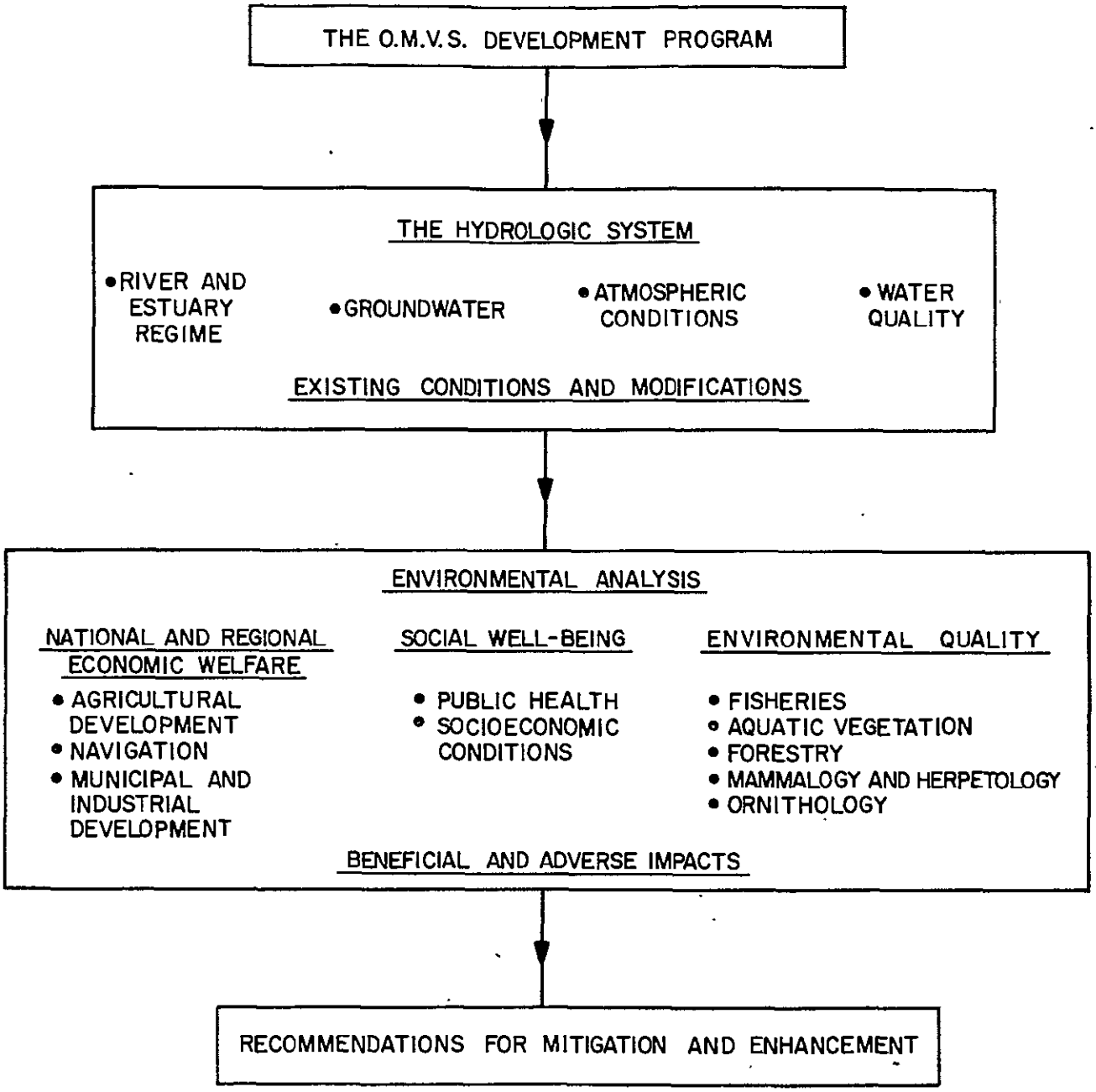
- River and Estuary Regime
- Groundwater
- Atmospheric Conditions
- Water Quality

are only beneficial or adverse when viewed in the context of certain other parameters.

Thus, the environmental analysis focuses on a second set of components, namely:

- National and Regional Economic Welfare
- Social Well-being
- Environmental Quality

The results of this analysis are viewed in terms of beneficial or adverse impacts for which recommendations leading to mitigation and enhancement are developed.



AN ENVIRONMENTAL SYSTEMS ANALYSIS

RIVER AND ESTUARY REGIME

The Senegal River System is the second longest in West Africa, flowing first north and then west from the Guinea highland forests to the Atlantic Ocean 10 kilometers south of St.-Louis. The Senegal River obtains nearly all of its yield from the Bafing, Bakoye and Faleme Rivers. Low flows do not provide enough water for agricultural needs or navigation during the annual January to July dry season and even during certain August to December wet seasons.

The meandering Senegal River in the Valley.

Existing Conditions

Important hydrologic characteristics of the river system related to drought conditions and water uses are as follows:

- One half of the average annual flow in the Senegal River at Bakel originates from areas that drain to the Bafing River upstream of Manantali.

The Bafing River. The major tributary in the headwaters of the Senegal River.

- Average annual flows recorded at Bakel vary from 270 to 1200 cubic meters per second. Extreme flows at Bakel vary from 10 cubic meters per second between March and June to approximately 4100 cubic meters per second during an average flood which normally occurs between September and November.

- River flows decrease downstream of Bakel due to evaporation, storage and infiltration of water to the floodplain. Little flow enters the Senegal River in the River Valley or Delta regions.

- The floodplain is inundated primarily by marigots that meander throughout the floodplain rather than by overbank flooding.

Between 100,000 and 840,000 hectares of land are flooded annually throughout the length of the floodplain.

- Water levels within the Senegal River as far upstream as the Podor-Boghe area are controlled during the dry season by tidal influences.

- Sediment is transported primarily by flood flows from the Bakoye and Faleme Rivers. It is believed that forty to fifty percent of the sediment load is deposited on the floodplain.

Widely-varying year to year hydrologic conditions limit the validity of generalized statements about existing or future hydrologic conditions within the Basin.

Projected Modifications

When the Diama and Manantali dams are in operation, flows, floodplain inundation and water levels will vary due to the natural hydrologic conditions already described; sizes and locations of future agricultural perimeters; release schedules from the Manantali reservoir; and backwater from the Diama dam.

The Diama dam will block tidal influences upstream of Diama and concurrently allow some flood waters to be stored behind the dam during dry seasons. The freshwater stored behind the Diama dam will be useful on a limited scale to provide more frequent recharge of Lac de Guiers and other Delta depressions, and to provide water for irrigation at agricultural perimeters in the Delta.

Controlled Manantali reservoir releases will provide sufficient water for the irrigation of 255,000 hectares along the Senegal River; year-round navigation as far upstream as Kayes, Mali; recharge of Delta depressions; hydroelectric power generation; and other uses. Large floods will not be regulated because the Manantali reservoir will not provide sufficient storage.

Smaller floods will be regulated. Small and average-size floods (but not necessarily proposed artificial flood releases) will yield reduced floodplain inundation and reduced peak water levels downstream of Manantali. The hydrologic changes associated with small and average-size floods will be least noticeable at St.-Louis, and most noticeable at Bakel and locations further upstream as far as Manantali. Development of diked agricultural perimeters will further reduce the amount of land inundated within the floodplain. These perimeters will also tend to raise water levels downstream of Bakel during larger-than-average floods.

Water level fluctuations behind the Manantali dam will alternately inundate and expose 230 square kilometers of land.

The Manantali dam and other proposed developments are not expected to significantly alter sediment transport within the Basin. Very little sediment is transported by the Bafing River through the Manantali area. Flood flows in the Delta are expected to be flushed through the Diama reservoir with little effect on sediment deposition into the estuary.

The proposed entry channel through the Langue de Barbarie will result in eventual formation of a lagoon south of the entry channel from what is now the Senegal River, and changes in sand deposition along the ocean beaches on both sides of the channel.

Short term, adverse environmental impacts, such as increased erosion and transport of sediments will occur, due to the construction of the two dams, the navigation channel and the estuary harbor-entry channel facilities.

GROUNDWATER

The Senegal River is a principal source of recharge for the three major aquifers in the River Basin. These aquifers are the Senegal River Alluvium, the Continental Terminal and the Maestrichtien Sands. Presently, wells in the Basin are shallow, making use of only the Senegal River Alluvium and other shallow water-bearing formations. Wells in these formations are generally two to 10 meters deep and are often hand dug. The Continental Terminal and Maestrichtien Sands are deeper formations and can only be exploited with drilling equipment.

Existing Conditions

Most of the groundwater resources of the River Basin are located in Senegal, although the Continental Terminal and Senegal River Alluvium are shared by Mauritania and Senegal.

- Recharge of the Senegal River Alluvium is derived from the river channel, the inundated floodplain, and rainfall. It is a significant source of water for the inhabitants of the Valley. The exploitable resources are estimated at 50,000 to 100,000 cubic meters of water per square kilometer of aquifer in the Basin.

- Within the Basin, the Continental Terminal aquifer is recharged primarily by the river channel and other inundated areas in the downstream reaches of the Basin. The exploitable resources throughout this sand/sandstone aquifer are 400,000 to 900,000 cubic meters of water per square kilometer of aquifer area.

- The major sources of recharge to the Maestrichtien aquifer in the Basin are the Senegal River channel and the Lac de Guiers area. Exploitable resources of this sand/sandstone aquifer are 250,000 to 500,000 cubic meters of water per square kilometer of aquifer area.

- Aquifers that extend downstream from Podor may be somewhat affected by annual salt intrusion from the Senegal River.

- Groundwater use is presently limited to domestic and livestock consumption. Nearly every village located away from a river depends on groundwater obtained from wells.

- Industrial and agricultural groundwater use is essentially nonexistent.

- Groundwater quality in deep aquifers has not been affected by any human activity.

- The quality of shallow groundwater supplies is altered in areas where wells located close to human activities become contaminated. This results from improper well construction and a lack of adequate maintenance activities.

Improperly placed and constructed wells in the Senegal River Basin lead to contaminated potable water supplies. Note animal trough in the background.

Projected Modifications

Basin-wide changes in the use of groundwater are not anticipated to result from the proposed development activities. Agricultural activities and large municipalities will exploit nearby surface water supplies. Throughout the Basin, the intensity of development that will require the use of groundwater supplies is not expected to exceed the rate at which aquifers are replenished. Where intense exploitation may occur, deeper mechanically-dug wells would be required.

Construction of the Diama dam will reduce saltwater contamination of aquifers from the Senegal River upstream of the dam. However, it is not certain that groundwater quality along the river in the Delta and Middle Valley will improve significantly. It has been suggested by some observers that the salinity is caused by old groundwater as well as intrusion from the Atlantic Ocean. Moreover, saltwater contamination from the River downstream of the dam will increase after the proposed entry channel south of St.-Louis is in place.

Construction of the Manantali dam and irrigated perimeters will alter groundwater recharge characteristics in the River Valley and Delta. Reduced flooding during years of average wetness and diking of large areas within the floodplain will change the extent and location of local recharge depending upon annual flood characteristics and the perimeter locations.

Some contamination of groundwater may occur from future agricultural, municipal and industrial activities. Fertilizers and pesticides may deteriorate groundwater quality in the River Valley and Delta, depending upon agricultural practices and soil conditions. Municipal and industrial wastes could create groundwater quality problems near these activities depending upon the types and extent of pollution control measures to be implemented. Wells near development activities will become contaminated if wells are not properly constructed and maintained and if the location of wells, with respect to development activities, is not appropriate.

Modifications in groundwater quantities due to proposed developments will not affect usage of aquifer resources in the next fifty years. Localized changes in groundwater quality and well contamination will depend, in part, upon what actions will be initiated to inhibit contamination and the extent to which these actions are executed.

ATMOSPHERIC CONSIDERATIONS

The climate of the Senegal River Basin varies from semiarid in the north to tropical in the south. Rainfall is the climatic element that shows the greatest variation in the Basin, with annual precipitation ranging from approximately 250 millimeters in the north to 2000 millimeters in the south. Recently, the number of drier-than-average years has exceeded the number of wetter-than-average years, a condition that encourages desertification.

Existing Conditions

- Based on an analysis of evaporation rates for the Basin, it is estimated that water evaporated from the Diama and Manantali reservoirs and irrigated perimeters would amount to less than 0.2 percent of the water vapor that flows across the Senegal River Basin air space.

- Changes in temperature and relative humidity that can be attributed to effects of man-made lakes and irrigation will not be evident more than a few meters away from the water surfaces.

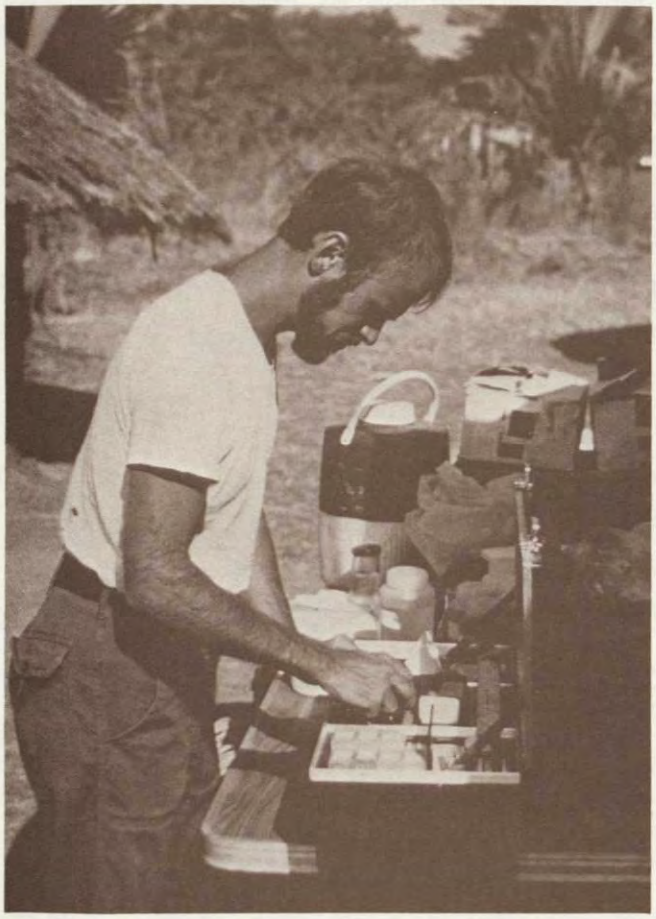
Projected Modifications

The new lake surface at Manantali and removal of trees that have acted as wind-breaks or wind-channeling devices will result in wind speed and wind direction changes that will be of comparatively small magnitude.

Proposed tree farms, if properly located, will act as wind-breaks, causing micro-climatical changes, reducing evaporation and aerial soil losses on irrigated perimeters.

WATER QUALITY

Effects of human activities on surface water and groundwater quality within the Senegal River Basin are at present hardly noticeable. Water quality changes that occur are primarily due to seasonal variations in river flow characteristics.



Water quality analysis by a member of the study team.

Existing Conditions

The principal water quality parameters addressed by this study are salinity levels in the estuary and the amounts of nutrients, minerals and organic materials that are washed down the river from upstream areas. Water quality characteristics, as evidenced by past literature and field observations during this study, are as follows:

- Intrusion of saline waters containing nutrients and other dissolved materials from the ocean extend as far upstream as Podor during the latter portions of many dry seasons, lasting from February through mid-July. During the annual flood, these waters are flushed from the Senegal River back into the Atlantic Ocean.

- Dissolved oxygen concentrations are not presently affected by municipal and industrial discharges or other effects of human activities.

- Nutrients, minerals, and to a lesser extent, organic materials enter the Senegal River during the wet season, primarily from percolation through the soils in the Fouta Djallon Mountains of Guinea. In these mountains are located the headwaters of the Bafing, Bakoye and Faleme Rivers, tributaries of the Senegal River. Nutrients in the main river channel of the Senegal River are predominantly in the dissolved state. Sediments are primarily inorganic, silty materials originating in the lower stretches of these rivers where erosion and surface runoff predominate. After inundation of the floodplains and when the main channel becomes ponded, these nutrients, along with those nutrients of terrestrial origin become tied-up in the particulate state in the form of plankton and higher aquatic plants. With the receding flood waters and the desiccating condition of the dry season, the plants die and decay. In turn, these nutrients contribute to the growth of terrestrial vegetation and crops produced by traditional methods such as recession farming. With the coming of the next floods, the nutrient cycle begins anew.

Projected Modifications

The Diama dam will act as a barrier preventing dry season salinity intrusion upriver from Diama and into adjacent groundwater. Without constructing the Diama dam, proposed releases from the Manantali reservoir would not prevent salinity from intruding upstream of the Diama area.

The Diama dam and the proposed navigation channel through the Langue de Barbarie will increase dry season salinity levels downstream of the dam. Releases of water from the Manantali reservoir during small and average-size floods will not completely flush the saline waters from the area downstream of Diama.

With development of the Basin, there will be larger amounts of human wastes from municipal areas, increased agricultural drainage waters from irrigated perimeters containing nutrients, fertilizers and oxygen demanding materials, and oil from increased navigational activity discharged to the Senegal River. These could noticeably affect water quality during low-flow periods. Significant changes in dissolved oxygen, nutrient and organic concentrations, however, are not expected from these activities if minimum attention is given to mitigation.

The Manantali reservoir will stratify thermally each year between February and December. During stratification, deeper waters will experience oxygen depletions and, possibly, accumulation of hydrogen sulfide that is toxic to aquatic life. During the period of stratification, proposed releases of bottom waters from the Manantali reservoir will result in reduced dissolved oxygen concentrations and the appearance of hydrogen sulfide in the Bafing River for a distance of at least seven kilometers downstream of the Manantali dam. Fish kills from hydrogen sulfide will be evident in this stretch of the river during stratification. Between December and January, waters in the reservoir will destratify, increasing oxygen concentrations throughout the water column and in turn reducing hydrogen sulfide levels. The initial release of hydrogen sulfide into the surface waters of the reservoir could result in a fish kill each year at the time of destratification.

Changed flow conditions and increased human activities as the result of proposed developments will alter the delivery of nutrients and organic materials to the River Valley. Hydrologic changes will increase dry season levels and reduce the transport of these materials during annual floods. Inputs from the ocean will no longer be available upstream of the Diama dam.

The alteration of nutrient loading by Basin development from the River to the estuary in the Lower Delta will be more than offset by the nutrient rich near-shore upwelling that occurs each year along the coast and off the mouth of the Senegal River from December through May. These nutrients will be cycled from the ocean into the estuary, contributing to the aquatic productivity of the Lower Delta. More importantly, the expected modification of the estuarine salinity regime from the Diama dam will play a major role in decreasing aquatic productivity in the Delta. The decreased inundations and decreased recycling of nutrients on the floodplains will result in further reduction of aquatic productivity in the Basin.

Short-term changes in sediment levels in the Bafing and Senegal Rivers are expected during construction activities. When excavation begins at the Diama and Manantali sites, increased sediment will be carried to the Bafing and Senegal Rivers. Sediment transport will particularly intensify from runoff in the Manantali area, however, control measures at the sites could easily moderate these temporary water quality changes.

AGRICULTURAL DEVELOPMENT

Most of the population of the Senegal River Basin is currently engaged in subsistance agriculture. Incomes are low and there are some food deficits. The three O.M.V.S. Member States currently require large imports of foodstuffs. One-third of the gross national product of the O.M.V.S. Member States comes from agriculture, and three-quarters of the labor forces in these countries are employed in agriculture and related activities. The urgent need to increase production was particularly evident during the disastrous 1968-1973 drought.

Improperly maintained irrigation canals clogged with the semi-aquatic plant, Cyperus.

Observations

- Most agricultural operations, from land preparation to harvesting, are performed manually.

- Variations in rainfall and unregulated river flows limit agricultural yields.

- Farmers lack proper training in irrigation techniques and water management.

- Existing irrigation systems are not efficient and water losses are extreme.

- Land parcels are not properly leveled.

- Maintenance of the existing conveyence systems is not being performed regularly.

- The irrigated perimeter development program is behind schedule.

- Overgrazing in the Basin, primarily by cattle, goats and sheep, has been a leading factor in hastening encroachment of desertification.

- The extension services are not adequate in size nor have the personnel received adequate training for them to effectively train and direct the farmers.

- Certain livestock diseases, such as foot-and-mouth disease, limit the potential export market.

Beneficial Impacts

- Elimination of saltwater intrusion upstream of Diama dam site.

- Storage of sufficient freshwater above Diama prior to Manantali construction will allow for initial expansion of a double-cropping irrigated agriculture system on a year-round basis.

Increased crop yields from properly managed irrigated perimeters.

- Construction of Manantali dam will provide for sufficient water to irrigate 255,000 hectares of irrigated perimeters, including 28,000 hectares of forage to feed livestock, on a year-round basis.

- Release of an "artificial flood" for 15 years following construction of the Manantali dam will provide water for 100,000 hectares of recession farming and for existing perimeters during the transition period from traditional to intensive irrigated agriculture.

- The proposed development will result in crop diversification and increased yields, as well as expansion of export crops.

- Improved navigation will permit barge transport of cattle. This will open up new markets for the sale of livestock and decrease weight loss associated with conventional trekking.

- Proper use of forage from the irrigated perimeters during the dry season along with implementation of range management practices can

act as an important deterent to desertification that is caused by overgrazing.

- The proposed development will increase the national food supplies, decrease malnutrition, improve the agricultural economy, contribute to the improvement of the overall national economies, increase employment opportunities in agriculture and related activities, and improve incomes and living standards of farmers of the Basin.

Adverse Impacts

- Construction of the Diama dam will increase groundwater levels, causing waterlogging of the soil in some portions of the Lower Delta and possibly increase soil salinity, especially during the dry season.

- Flow augmentation below the Manantali dam will result in the permanent loss of approximately 5,000 hectares of recession agriculture land along the riverbanks.

Traditional farming on flood recession lands.

- Construction of new irrigated perimeters will disrupt recession farming in the Basin and could result in a food deficit in the Basin during the irrigated perimeter construction period.

- Crop pests and crop diseases will increase as agriculture intensifies and new crops are introduced.

- Loss of dry season forage by conversion of flood recession land into irrigated perimeters may force cattle onto marginal grazing land and hasten desertification unless proper land use management practices are instituted.

- The distribution of dikes and canals associated with irrigated perimeter development could block traditional migratory cattle routes to and from the Senegal River.

The failure to properly implement this development program will lead to an erosion of national food supplies and corresponding deterioration of both the Basin and national economies. Nutritional deficiencies would be widespread.

NAVIGATION

Various development activities will allow year-round navigation between Kayes, Mali and the Atlantic Ocean. These activities include dry season releases from the Manantali reservoir, an expanded river channel, new and expanded port facilities, a navigation lock at Diama, modification of the Faidherbe Bridge, a deep water harbor at St.-Louis and an entry channel through the Langue de Barbarie. Ocean-going vessels will be able to transfer goods to and from river barges at St.-Louis.

Observations

Navigability along the river for vessels with less than a one meter draft varies from 365 days per year between St.-Louis and Podor to 120 days per year between St.-Louis and Kayes. River traffic was slowed considerably in the 1960's when the all-weather road paralleling the river went into place. Existing conditions that limit navigation are the following:

- A shallow and unstable River mouth.
- Low water levels upstream of Podor during the dry season.
- Locations along the Senegal River with insufficient width and turning radius for the passage of barges.
- River-going vessels that are too few in number and inefficient for transporting goods.
- Port facilities that are not adequate for large-scale navigational operations.

Typical commercial vessel on the Senegal River between St.-Louis and Richard Toll.

Beneficial Impacts

- Importation and exportation of goods will increase revenue and employment opportunities within the three O.M.V.S. Member States.
- National and regional economies and Basin inhabitants will be benefited, particularly in Mali.

Adverse Impacts

- Construction activities will encourage additional releases of sediments to the Senegal River.
- Barges may be obstructive to artisanal fishing boats.
- Wave action from barges could encourage river bank erosion, depending on the extent of barge activities.

- Dredging and barge traffic will resuspend bottom muds in the Senegal River channel.

- The entry channel will increase salinity in the Senegal River downstream of the Diama dam.

- Potentially hazardous materials such as pesticides and fertilizers will be transported upriver by barge. Mined phosphorous will be transported downriver as an export product. If any of these materials are accidently discharged in large amounts into the Senegal River during transport, they could adversely impact the aquatic ecosystem to a significant degree.

- Vessels and port facilities will intermittently discharge oil and waste products to the Senegal River, either intentionally or by accident.

Discharges of oil and waste products have the greatest potential of any of the projected adverse changes from navigation for noticeably degrading the natural environment. Overall, the beneficial impact of navigation is expected to overshadow the potential adverse environmental changes, assuming the avoidance of a disasterous accident.

MUNICIPAL AND INDUSTRIAL DEVELOPMENT

Within the Senegal River Basin, municipal and industrial development exists where water is available. The extent of municipal and industrial growth is currently limited by the availability of water and capital that are needed to commence large-scale activities. Existing industries within Mali are: cement production, abattoirs, and groundnut processing. Industries within Senegal include tomato canning, rice processing, sugar refining, quick lime production, plastics production, fish refrigeration, and an industrial abattoir. Abattoirs are also in operation at Kaedi and Rosso, in Mauritania.

Sugar refinery at Richard Toll, the major agro-industry presently in the Senegal River Basin.

Observations

Water supply and waste disposal considerations for existing municipal development are as follows:

- Sources of water are the Senegal River and its tributaries; pools of surface water formed from rainfall and flooding; and shallow hand-dug wells located throughout the Basin. Pools of water that are reused a number of times for various water needs become transmitters of disease.

- Water treatment and distribution systems at municipalities adequately serve only a minor fraction of municipal inhabitants.

- Waste disposal methods within the Basin include sewers in a few urban areas, but are otherwise limited to night soil collection, latrines and open field defecation.

Improperly maintained open sewers such as at St.-Louis can lead to contamination of potable water supplies and may harbor disease vectors such as rats and mosquitos.

- Municipalities within the Basin do not have adequate liquid or solid waste disposal facilities to minimize disease transmission from these sources.

Beneficial Impacts

- Opportunities for municipal and industrial growth will be greatly enhanced by the proposed O.M.V.S. development program. Year-round water needs will be met by annual floods, dry season water releases from the Manantali reservoir and by the Diama dam blocking saltwater intrusion. As agricultural production increases and projected agro-industries develop, national economies will become more self-sufficient and standards of living will rise.

- Releases from the Manantali reservoir will result in free flowing conditions in river channels downstream of Manantali throughout the year. In these areas, pools of water will not be present to transmit diseases during the dry season.

- Future increased flows and blockage of saltwater intrusion will allow Lac de Guiers and other Delta depressions to be recharged and to be more reliably used for development activities.

Adverse Impacts

- With reduced flushing action in the Senegal River below the Diama dam, the Lampsar and Djeuss marigots may not satisfy the yearly water supply needs of St.-Louis.

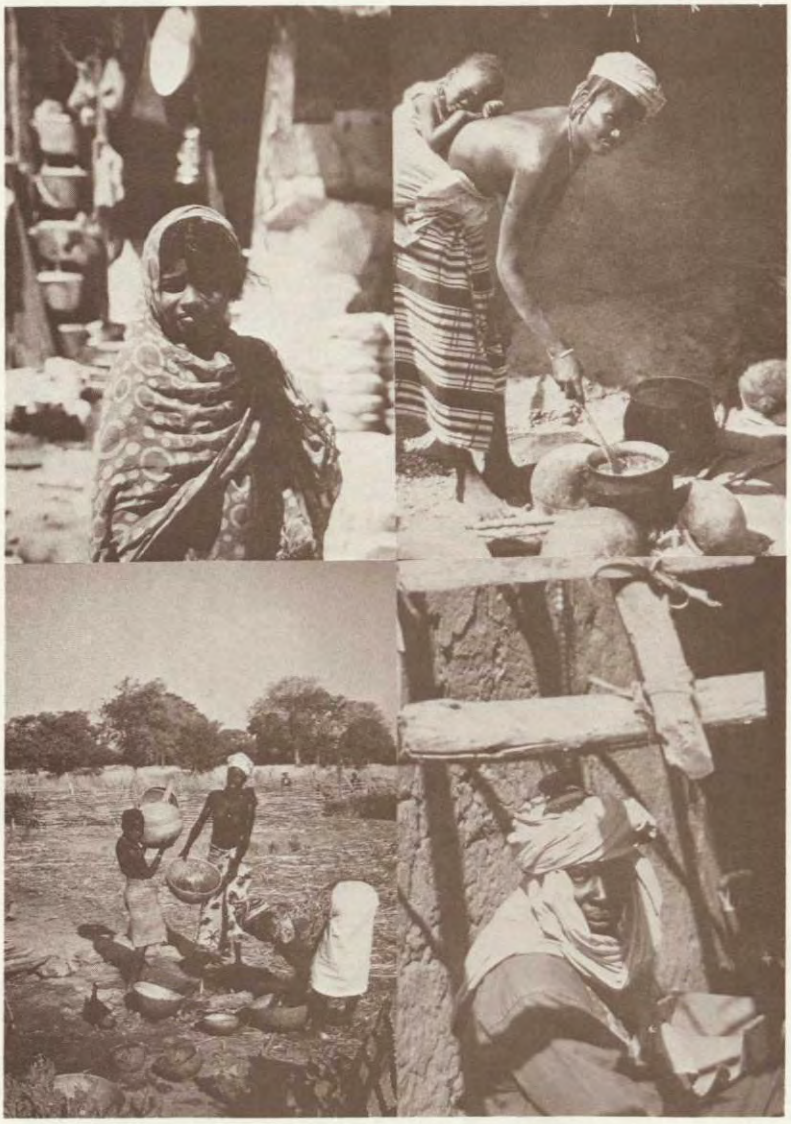
- Large influxes of people to municipalities as a result of development could intensify public health and socioeconomic concerns.

- Future, inadequately treated discharges of municipal wastes or industrial wastes from agro-industries could create localized public health and oxygen depletion problems in the Senegal River.

Within the next 50 years, major changes are expected to take place in the Senegal River Basin due to implementation of the O.M.V.S. development program. Detailed planning for municipal and industrial growth should be undertaken as soon as possible if adverse impacts are to be avoided.

SOCIOECONOMICS

During the Middle Ages, pressures from moving Berbers and increasing desertification forced sedentary agriculturists to migrate into the Senegal River Basin from the central Mauritanian Plateau. The influence of French colonialism and the development of a cash economy with cultivation of peanuts hastened further migration into the Basin. By the 1940's, continued encroachment by the Sahelian zone and a failing cash economy forced and continues to force large numbers of working-aged males out of the Basin, especially from the Tukulor and Soninkie tribes.



Ethnic and cultural diversity of Basin residents.

Observations

- Tribal groups can be geographically delineated moving upstream from the mouth of the Senegal River. In order of appearance, they consist of the Wolof, Tukulor, Soninkie, Khassonkie and Malinkie. The Fulbe are pastoralists scattered about the Basin.

- Presently, the primary economic activity in the Senegal River Basin is subsistence agriculture, which generates half of the wealth within the Basin.

- Social structures are based on a corporate kinship group, the extended family, that traces its lineage from a common male line.

- A caste system that controls the distribution of cultivable land also exists.

- The present population in the Senegal River Basin is estimated to be approximately 1.7 million.

- Assuming natural population growth, the 2028 population of the Senegal River Basin is projected to be approximately 6.3 million. This projection does not include ajustments for outward migration from the Basin.

- Under traditional agricultural practices, it is common for most artisans to work as cultivators during the rainy season and pursue their crafts during the dryer time of the year. This includes crafts such as leather and woodworking, pottery, and handmade fabrics.

Beneficial Impacts

- Basin development will decrease out-migration by providing greater employment.

- There will be a gradual return from a subsistence economy to a cash flow economy, enabling increased buying power. In rural areas where traditional lifestyles will still prevail, bartering will continue; although there will be an increasing tendency in villages for the sale of agricultural products for cash to purchase material goods.

- Agricultural activities on irrigated perimeters with the O.M.V.S. project are projected by 2028 to support 1,453,500 people out of a projected rural population of 4,814,900 persons. The remaining rural populace will continue to exist by traditional lifestyles.

- The remaining urban populations will be supported largely by agro-industries and related services in major urban centers such as St.-Louis and Kayes.

- There will be an increase in industrial jobs involved with processing agricultural products. This includes employment in vegetable canneries, cotton gin spinning and weaving mills, sugar refineries, abattoirs, tanneries, dairy plants, and lime and processing plants.

- Under O.M.V.S. guidance, navigation and industrialization activities are projected to employ approximately 72,000 wage earners by 2028. This will produce an additional 83,000 service related jobs such as merchants, masons, repairmen, barbers, butchers, and taxi drivers.

Adverse Impacts

- Inundation of land behind the Diama and Manantali dams will displace residents from important religious grounds. A struggle for control of leadership may develop between the various village heads as communities are combined. Friction may occur between existing populations and the relocated villagers for control and distribution of building materials, water supplies, schools, dispensaries and agricultural lands. These tensions could cause a decline of authority as well as social instability of the displaced villagers.

- Development of the Basin will result in a decrease of traditional activities such as herding, fishing, rainfed (dieri) and floodplain (recession) farming.

- Higher wages of dam construction workers will draw working age males from great distances, thereby diminishing the authority of the extended family and temporarily decreasing labor available for working agricultural lands.

- Urban poverty is predicted to increase as job hunters quickly surpass available jobs.

- Greater urbanization will place increasing pressure on the government to provide planning and other municipal services.

- Traditional allocation of agricultural lands by the caste system, and inheritance by parcelling will be modified under the government controlled irrigation perimeters. This may result in social tensions and social instability.

- The historically independent farmer will become increasingly dependent on government for agriculturally related activities.

Spinning raw material into thread - a traditional craft in the Basin.

- Under irrigation agriculture, which allows double cropping, traditional craft activities will decline as more and more of the artisan's previously free time becomes committed to cultivation. This cultural impoverishment will be hastened as salaried workers become able to buy imported goods manufactured outside the Basin.

In terms of planning for future population growth in urban and rural areas, a crucial role for O.M.V.S. will be to predict and interpret the expected effects of Basin development on population movements, economic potentials, land availability and social infrastructure requirements to national, regional and local officials.

PUBLIC HEALTH

The principal health problems in the Senegal River Basin are malaria, nutritional disorders, fecally related and airborne diseases. Other diseases, such as plague, yellow fever, meningoccal meningitis, and cholera have been quiescent in the Senegal River Basin in recent years. Urinary schistosomiasis is focally endemic but prevalence is not high. Onchocerciasis occurs in the Upper Basin. Venereal diseases and leprosy are of health significance. Surprisingly, tuberculosis does not appear to be a problem of much importance in the Basin, except to children.

Observations

- Prevalence of malaria is lowest in the Delta where there is the least rainfall, and highest in the Upper Valley, where the rainy season is longest.

- Levels of malaria infection observed by the health surveyors during this environmental assessment project were lower than in earlier years, due to two consecutive previous years of low rainfall.

- Urinary schistosomiasis is present throughout the River Basin but the prevalence of infection is generally low. It is more common in the Upper Basin but, even there, infection rates are not high. Although previously reported, no cases of intestinal schistosomiasis were found by this Study's field team.

- Onchocerciasis is an important health problem for riverine communities in the Upper Basin. Infection rates in this region generally are found to range between 10 and 50 percent, with some localized higher rates of infection.

- Nutritional disorders are prevalent in children under seven years of age, although severely affected children are uncommon.

Malnourishment evident from the frail frame and bloated belly of a child in the Senegal River Basin.

- Fecally transmitted diseases, particularly intestinal infections, poliomyelitis, and intestinal worms, are not a major cause of illness in infants and young children.

- Airborne diseases are major health problems in the Basin, especially among children. Measles, tuberculosis and pertussis are the most significant diseases associated with the respiratory tract.

Beneficial Impacts

- The impoundments at Diama and Manantali are not expected to significantly increase malaria transmission.

- Schistosomiasis transmission in the Delta, presently insignificant, is not expected to show much change with construction of the Diama dam. It does not appear that the Delta region will provide a suitable environment for either efficient disease vector snails or for schistosome larvae.

- Onchocerciasis will disappear from the portion of the Senegal River in the Upper Valley to be innundated by the Manantali impoundment because of the destruction of the black fly breeding habitat.

- Irrigated agriculture will improve the overall quality of nutrition in the Basin communities.

- Development of properly constructed and maintained water supply systems will result in a decrease in prevalence of fecally transmitted diseases.

Adverse Impacts

- Vector mosquito breeding and subsequent malaria transmission is expected to increase locally in the upper portion of the Middle Basin as a result of irrigated perimeter construction.

- It is expected that the Manantali impoundment will have favorable vector snail breeding conditions, resulting in a significant increase in schistosome infections in that vicinity.

- Flow augmentation below the Manantali dam will provide a more stable and improved habitat for blackfly breeding on a year-round basis. This is expected to result in a higher prevalence of onchocerciasis near the Bafing and Bakoye Rivers between the Manantali dam and Kayes.

- During the construction phase of the Manantali dam, the construction workers will be exposed to communicable diseases.

- Resettlement, immigration and urbanization will, most likely, result in increased transmission of both fecally transmitted and airborne diseases, particularly during the construction phase of the program.

It is anticipated that the overall impacts of the O.M.V.S. development program on health will be favorable. There are, however, adverse impacts which have been noted. It is felt that an effective mitigating measure against the expected adverse health impacts of the development program is the development of a primary health-care system within the Basin.

FISHERIES

The fishery of the Senegal River Basin is regulated by two climatic extremes, the wet and dry seasons. During the wet season from August through December, the Middle Valley and Delta exhibit characteristics of a freshwater fishery. This fishery relies on inundation of floodplains to replenish fish stocks by providing breeding and nursery grounds for various species. During the dry season, a saltwater wedge moves upriver, creating an estuarine fishery.

Observations

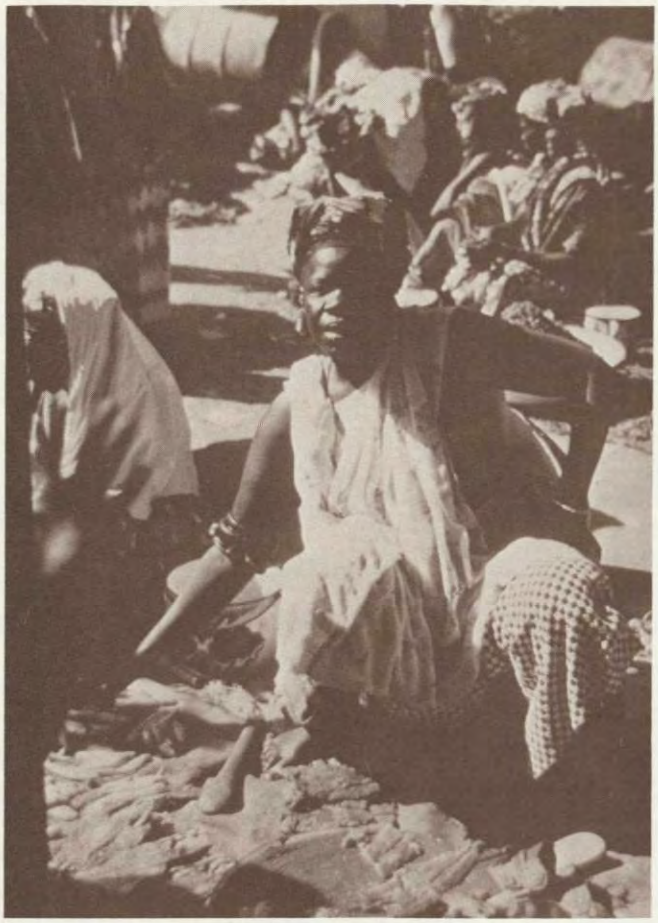
- Based on an average annual flood inundating 550,000 hectares, major fish habitats and annual average harvests in metric tons of fresh fish per year include: Lac de Guiers/2250; Aftout es Sahel/5; downstream of the proposed Diama dam/4000; upstream of the proposed Diama dam/7500; and floodplains/33,000.

- The life cycle of the commercially important pink shrimp is tied to the development of estuarine conditions in the Senegal River. Annual pink shrimp harvests in the ocean off the Senegal River have declined from a high of 265 metric tons in 1974 to a low of 100 metric tons in 1976. This decline has been attributed to either overfishing, cyclic population fluctuations or to the decreased nursery grounds from the low flow of the Senegal River in recent years.

- The African Shad, whose life cycle is also tied to estuarine conditions, is only a small contributor to the commercial marine fishery but is important in the artisanal fishery at the mouth of the Senegal River.

- All freshwater fish that are caught are consumed, regardless of size.

- Marine fish are transported to upriver markets, supplementing river and estuarine fish harvests.



Marketing of fish in the Senegal River Basin.

- The average annual per capita consumption in kilograms of fish within the Senegal River Basin presently and projected for the year 2000 is 58 and 67 kg/c/yr respectively in Senegal, 15 and 22 kg/c/yr in Mauritania, and 15 and 15 kg/c/yr in Mali. This study projects a total annual demand for fish in the Senegal River Basin of 48,000 metric tons presently, 110,930 metric tons by 2000, and 240,000 metric tons by 2028. This increased demand can be attributed to increased annual per capita consumption. But more importantly, it can be attributed to the Basin's rapidly expanding population, which is projected to increase from its presently estimated size of 1.7 million to 2.9 million by year 2000, and to 6.3 million inhabitants by year 2028.

Beneficial Impacts

- Construction of the Diama dam will increase recharge of water to Lac de Guiers, Lac R'Kiz (presently dry) and Aftout es Sahel. This will provide a potential net increase in annual fish harvests of 500 metric tons in Lac de Guiers, 1200 metric tons in Lac R'Kiz and 5000 metric tons in the Aftout es Sahel. However, high salinities in the Aftout es Sahel could become a limiting factor.

- Creation of the Manantali impoundment will result in development of a freshwater fishery that should be exploitable at a commercial level. It is estimated that 3000 metric tons of fish, such as Tilapia and Sarotherodon, can be harvested annually. These fish have the potential to supply an important local source of protein to the resettled people whose villages will be inundated by the impoundment.

Adverse Impacts

- Elevated salinities in the Lower Delta downstream of the Diama dam will result in an annual decrease in fish harvests of 4000 metric tons. Any estuarine organism whose life cycle is tied to low saline conditions will disappear from the Senegal River. This will mean a loss of the African Shad and pink shrimp in commercial and artisanal catches off the mouth of the Senegal River.

- There will be a projected net annual loss of 3000 metric tons of harvested fish immediately upstream of the Diama dam. This will result from the destruction of the estuarine environment in the Upper Delta. The new freshwater fishery that is expected to develop has the potential to provide an annual fish harvest of 4500 metric tons. Additionally, there will be a change in fish stocks with regard to species and diversity.

- During an average flood, 550,000 hectares of floodplains are inundated. Alteration of the annual flood by operation of the Manantali dam will reduce inundation to 190,000 hectares, resulting in a projected loss of 21,600 metric tons of fish in the annual fish harvests.

The fisheries of the Basin have historically played a central role in providing protein to the basic diet of the Basin residents. The projected net decrease in annual fish harvests as a result of Basin development and the projected increase in fish demand by the expanding population will result in a net deficit in fish supplied for consumption from the Senegal River. The resulting protein deficit will have to be augmented by alternative sources, as detailed in the Plan of Action.

AQUATIC VEGETATION

Over 50 species of higher aquatic plants play an important role in the ecology of the Senegal River Basin. Emergent vegetation along the marshy edges of water bodies provides important habitat for a variety of bird life and semi-aquatic wildlife including mammals, reptiles and amphibians. Floating and rooted aquatic plants provide habitat for a variety of invertebrates that act as important sources of food for fish. These plants, along with epiphytic algae and phytoplankton also act directly as food for some species of fish. Habitat is also provided by aquatic plants for fish breeding, as a nursery and for refuge, being especially important in the seasonally inundated floodplains of the Senegal River. In the quieter backwater habitat of the floodplains and Lac de Guiers, higher aquatic plants, epiphytic algae and phytoplankton are important in replenishing the life-giving oxygen throughout the water column. Certain species of aquatic plants, such as Ceratophyllum, Nymphaea and Pistia, provide habitat for the snail vectors of schistosomiasis. Aquatic plants, such as Pistia, may at times reach nuisance levels, inhibiting fishing and artisanal navigation activities.

Inundation of a ponded area with Nymphaea and other aquatic plants.

Observations

- Higher aquatic plants in the Basin are restricted during much of the year to permanent quiescent bodies of water such as Lac de Guiers, Aftout es Sahel and Djoudj Park. Higher aquatic plants are most prolific during the rainy season covering large areas of the inundated floodplains.

- Higher aquatic plants in the main channel of the Senegal River are limited by seasonal water fluctuations, the annual flood that tends to flush these plants out of the Basin, and turbidity.

- Water level fluctuations, wave action and turbidity limit higher aquatic plants to the edge of Lac de Guiers. At times, Pistia reaches nuisance levels, affecting fishing activities.

- Observations indicate that higher aquatic plants block flows in irrigation canals, and that transpiration results in loss of water that might otherwise be used for irrigation.

- During the dry season, plankton are abundant in quiescent water bodies such as Lac de Guiers, Aftout es Sahel and Djoudj Park and in the trapped pools of water of the main river channel.

- During the wet season, high flows and increased turbidity reduce plankton populations in the main river channel. At this time, plankton populations play a major role in supplying oxygen and food to the flood plain fishery in the Basin.

Beneficial Impacts

- Phytoplankton will play an increasingly important role behind the Diama and Manantali dams in providing oxygen to the water column, and in acting as a source of fish food.

- Wind and wave action will restrict development of nuisance levels of floating aquatic plants or mats of floating plants (Sudds) on the open waters of the Manantali.

- Water level fluctuations along the shoreline of the Manantali Reservoir will restrict the growth of rooted aquatic plants that could harbor the snail vectors of schistosomiasis.

- Emergent vegetation along the increased shorelines of the Manantali and Diama dams, the Aftout es Sahel and Lac R'Kiz will provide important wildlife and bird habitat.

- A major portion of the Diama reservoir (averaging less than 0.3 meters outside the main channel at the 1.5 meter IGN level) and the increased recharge of Lac de Guiers, Aftout es Sahel and Lac R'Kiz will provide excellent year round habitat for the proliferation of higher aquatic plants and plankton.

Adverse Impacts

- The increase in aquatic plant habitat discussed above cannot compare to the total biomass of plants lost from a projected 2028 decrease of up to 359,000 hectares of floodplain habitat for an average flood as the result of Basin development. This, in turn, will have a major adverse impact on the annual fish biomass available for harvest in the Basin.

- Increased nutrient levels downstream of agricultural, municipal and industrial activities could result in elevated levels of aquatic plant and plankton populations.

- Floating aquatic plants may reach nuisance levels in the protected dendritic arms of the Manantali reservoir.

- If uncontrolled, aquatic plants will reach nuisance levels, decreasing the performance of new and existing irrigation canals as well as providing habitat for disease vectors; in turn affecting the health of agricultural workers.

Although the net result of development will be an overall decrease of aquatic plants in the Basin, monitoring will be necessary, especially in the impoundments and irrigated perimeters, to assure that aquatic plants are controlled. This will minimize increases of habitats for disease vectors around population centers.

FORESTRY

Rainfall and vegetational zones closely parallel latitudinal lines in the Senegal River Basin. Two broad zones of vegetation exist within the study area: the Sudan zone from Bakel to beyond Manantali and the dryer Sahel zone covering the remainder of the Senegal River Basin. Three major forest types are distinguishable: the gonakie, the dryland and riverine dryland (dieri) in the Sahel zone, and the upland savanna forests of the Sudan zone. Managed or classified gonakie forests are protected from over-use by man and his domestic livestock, but have been severely affected by the recent drought. Unmanaged or nonclassified gonakie and dieri forests in the Basin are in a degenerated state from the recent drought, overharvesting by man for firewood and charcoal, out-of-control fires set by traditional agriculturists to generate fertilizer, and from overbrowsing by livestock. The destruction of these forests by such activities is considered a major factor in hastening desertification in the Senegal River Basin.

Acacia Tree.

Observations

- Primary uses of forests include commercial exploitation for firewood and charcoal, wildlife habitat, and grazing and browsing of domestic animals.

- Gonakie forests are monotypic, consisting almost exclusively of one specie of tree, Acacia nilotica. The Gonakie forest is the most valuable of the three forest types because of its commercial use as firewood and charcoal. Approximately 50,000 hectares of gonakie forest exist on both sides of the Senegal River in Mauritania and Senegal. However, this is only 0.17 percent of the land surface in the study area. These forests are not found in Mali.

- Dieri forests are multitypic, consisting of a variety of species. Dieri forests are much lower in productivity than gonakie forests. Approximately 15,000 hectares of nonclassified dieri forests exist in the study area. There are no classified dieri forests.

- Although presently in a degraded state, regional experts feel that dieri forests will be of key importance in future years as productive gonakie forests become reduced in size from developmental activities. The agricultural field team in this Study programmed perimeters around existing classified gonakie forests.

- The upland savanna forests are found in Mali and, because of increased rainfall, have a greater species diversity than the previous two forest types. Despite approximately 1200 mm of annual rainfall in the Manantali area, the forest resource is not extensive nor of much commercial value. The most valuable trees occur as fringe forests along the Bafing River and its tributaries.

Upland savanna forests.

- Between 1-1.5 steres (0.4-0.6 tons) of firewood are required yearly per person in the Senegal River Basin. Because even carefully managed classified gonakie forests cannot supply this need, dieri forests have been rapidly over-exploited. Recent increases in firewood and charcoal availability have been attributed to the increase in dead and dying trees on classified forests. Over-flights by the study team indicate approximately 33 percent and 43 percent, respectively of the classified gonakie forests in Senegal and Mauritania between Rosso and Matam have been killed by drought between 1972 and 1977. This lost timber is not being replaced, greatly reducing the productivity of these forests.

- While Senegal and Mali have forestry resources outside of the Senegal River Basin, Mauritania's timber reserves are limited to the Basin area.

Beneficial Impacts

- Creation of a barrier to saltwater intrusion by Diama dam may improve groundwater quality and result in decreased soil salinities,

improving conditions for growth of forests immediately adjacent to the Senegal River in the Upper Delta, upstream of Diama.

- Low-flow regulation during the dry season will ensure recharge of the groundwater, benefiting forests immediately adjacent to the river.

Adverse Impacts

- Inundation of 1000 hectares of gonakie forest from behind the Diama dam will mean a permanent loss of approximately 255,000 steres of firewood. These should be harvested before construction.

- Decreased floodplain inundation as the result of low flow regulation by the Manantali dam is projected to result in an estimated loss of approximately 7600 hectares of the remaining 37,900 hectares of gonakie forest downstream of the dam. This represents a volume loss of 1,817,000 steres. These losses are much less than have been lost due to the drought and overbrowsing by livestock.

- Permanent loss of 700 hectares of fringe forest and 42,900 hectares of upland savanna forest from inundation behind the Manantali dam.

- Possible loss of gonakie and dieri forests from agricultural development, although irrigation perimeters can be programmed so that they will not affect existing classified gonakie forests.

The failure to implement reforestation and proper land use management practices will result in a decrease in available wood supplies and wildlife habitat, and will hasten desertification.

MAMMALOGY AND HERPETOLOGY

The past two decades have witnessed a decline in wildlife throughout most of West Africa. Drought and activities by man are primary factors in this decline. The development of the Senegal River Basin is designed to increase the value of the Basin as a resource for man. Until now, wildlife management practices and potential impacts from development have not been considered in Basin-wide development plans.

Observations

- Wildlife habitat in the Senegal River Basin is largely determined by variations in topography and rainfall that influence the distribution and diversity of vegetational types.

- Superimposed upon these geographical determinants are land use practices by man, especially in the Lower and Middle Valleys of the Basin, which have resulted in degraded wildlife habitat throughout much of the region. Dieri farming has resulted in removal of indigenous vegetational cover. Over-grazing of savanna vegetation by sheep, goats and cattle has reduced the habitat and forage available for native herbivorous mammals, such as the elephant, gazelle and monkey. Large cats and other predators relying on these animals for food have correspondingly been reduced in numbers. Destruction of forests by drought and man-made fire, as well as uncontrolled harvesting of forests for charcoal and firewood has resulted in degenerated woodland habitat throughout most of the Basin.

- The lion has been eliminated by man from most if not all of the Lower and Middle Valleys because it is a menace to livestock. It still occurs in the Upper Basin from Bakel throughout the Senegal and Bafing River portions of the study area.

- The Senegal River and associated marigots, Lac de Guiers and Djoudj Park provide habitat for the endangered Nile Crocodile, (Crocodylus niloticus), and the threatened Senegal River Manatee, (Trichechus senegalensis). These populations have been greatly reduced from over-hunting and habitat destruction. They were not observed during the field portion of the environmental assessment project.

- In the less populated upper regions of the study area, wildlife has been less impacted by man and thrives in a more natural state.

Manatee.

Beneficial Impacts

- An increase in the year-round habitat of the Nile Crocodile and Senegal River Manatee in the Delta due to increased recharge of freshwater bodies as the result of low flow regulation by the Manantali dam and the prevention of saltwater intrusion by the Diama dam.

- The year-round presence of freshwater in the Diama impoundment will allow wildlife to colonize Delta areas formerly not available to them because of the lack of freshwater during the long dry season.

- Creation of Nile Crocodile and hippopotomus habitat behind the Manantali dam.

- Improved wildlife habitat along the periphery of the Manantali dam, benefiting Roan Antelope (Hippotragus equinus), Defassa Waterbuck (Kobus defassa), and Bohor Reedbuck (Redunca redunca).

- Increased habitat for various species of reptiles, amphibians rodents and other small mammals from the development of irrigation agriculture.

Adverse Impacts

- Loss of between 130 to 320 sq. km. of already degenerated habitat from inundation behind the Diama dam, affecting populations of warthog, jackal, rodents, serval, civette and genet.

- Manantee could become trapped and perish in highly saline waters downstream of Diama dam.

- Loss of terrestrial wildlife habitat from resettlement of villages to be inundated behind the Manantali dam.

- Loss of 42,900 hectares of upland savanna habitat and 123 kilometers of fringe forest along the Bafing River from inundation behind the Manantali dam, affecting populations of lions, serval, hyaenas, warthog, Oribi (Ourebia ourebi), Red-flanked Duiker (Cephalus rufilatus), Bushbuck (Tragelaphus scriptus), small mammals, reptiles and amphibians. Inundation will force many of these animals out of the area, while others will be lost due to drowning.

Many displaced animals will be forced onto habitat that is at carrying capacity for that specie. In such instances these animals will eventually die or be forced to move on until more sparsely settled habitat can be found.

- Loss of terrestrial wildlife habitat will occur from agricultural, industrial and urban development. Additionally, the human population will expand to 3.7 times its present size over the next 50 years. As a result, there will be increased competition between man and wildlife for the use of Basin lands, even in the rural environment.

Proper management practices can partially offset adverse conditions for wildlife, which is presently in a degenerated state, throughout the Basin. However, on balance, wildlife will continue to be at a growing disadvantage against the pressures of increased human populations and development activities.

ORNITHOLOGY

The wetlands of the Senegal River Basin constitute an important wintering habitat for migratory fowl that arrive from a vast area extending from Europe to Siberia. The most significant habitat is the Djoudj depression, which became a haven for waterbirds in 1963 when a system of dikes was built. This prevented the inundation of many Delta wetlands surrounding Djoudj in Senegal, permitted agricultural development and resulted in much wetland habitat destruction. These developments, however, resulted in longer retention of water in the Djoudj depression. While there are no bird species found with in the Basin that are directly threatened with extinction, there are seven species that are listed by the Convention on International Trade of Endangered Species of Wild Fauna and Flora. Six of the seven species were seen by the ornithology team during field trips. These are the Crowned Crane (Balearica regulorum), eagles of the genera Aguila and Haliaetus, harrier hawks (Circus), Osprey (Pandion haliaetus), and the European spoonbill (Platalea leucorodia). Scops owl (Otus scops) was the only endangered species that was not seen, although it has been listed as a wintering bird near Richard Toll.

The Crowned Crane.

Observations

- Due to drought conditions, waterbird populations observed in December, 1977 were far below normal levels at wetland sites in the Delta.

- Three species of duck, the gargany (Anas querquedula), pintail (Anas acuta) and white-faced tree-duck (Dendrocygna viduata), constitute 90 percent of the waterfowl population that migrate into the Senegal River Valley. The Senegal River Basin is one of only two wintering grounds available to the gargany, the other being the Interior Niger Delta of Mali.

- The greatest waterbird populations occur in the Delta but they are also well represented upriver. As the dry season progresses these waterbirds become concentrated in the managed Djoudj Park.

- Waterbirds were scarce in the Manantali area of the Bafing River during the May, 1978 site visit of the ornithology team. It is recognized that during this survey the drought conditions and time of year may have been unfavorable to bird congregations in this region of Mali.

- Population levels of sananna birds in the Valley were found to greatly exceed previously reported levels.

- Over the past decade, the population of the Rice Bird (Quelea quelea), a notorious grain crop pest, has declined in the Senegal River Valley.

- A number of other species of birds occurring in the Senegal River Valley also have been implicated in grain crop damage but not to the same extent as Quelea. These include several members of the genus Ploceus (weavers), the genera Euplectus (bishops) and Passer, especially Passer luteus (golden sparrow), a relative newcomer to the Senegal River area.

- Ciconia ciconia, the White Stork, which is strictly protected under the African Conservation Convention, was identified by the ornithology team at Djoudj Park during winter.

Beneficial Impacts

- Increased waterbird habitat (marshy perimeters) resulting from construction of Manantali and Diama impoundments, maintenance of water levels in Lac de Guiers, Lac R'Kiz, Aftout es Sahel and irrigation canals.

The White Pelican in formation - a common migratory water bird in the Basin.

- Increased food supplies for waterbirds, initially at Lac de Guiers and, in the long term, at the Manantali and Diama impoundments. These food supplies will come from year-round growth of emergent vegetation, aquatic plants, fish and invertebrates.

Adverse Impacts

- Construction of the Diama dam will cause a loss of estuarine fishes, resulting in a corresponding decrease in fish-eating bird populations.

- Inundation of reservoir sites and irrigated perimeters will decrease available habitat for savanna birds.

- Increased agricultural productivity will lead to a large increase in population sizes of granivorous bird species. This is a long-term, positive impact for bird species but will result in a negative impact to man from decreased crop harvesting.

- Widespread use of pesticides in irrigated perimeters could result in the concentration of pesticide residues in body tissues of insectivorous and graniverous birds. Bioaccumulation of pesticides in fish-eating species could also occur by runoff of pesticides or discharge of drainage waters from the perimeters into the aquatic ecosystem and the subsequent contamination of fish.

The overall thrust of the Plan of Action should be to mitigate the adverse impact from granivorous bird populations while, at the same time, protect the habitats of birds that are not harmful to man and his activities.

CHAPTER III

RECOMMENDATIONS

It is the concensus conclusion of the technical specialists who served on this project that the benefits to be derived from the O.M.V.S. development program by the citizens of the Senegal River Basin far outweigh the adverse consequences projected as a result of this Study. Assuming those actions recommended herein for mitigation purposes are to be undertaken, no reservations should exist with regard to the recommendation that the O.M.V.S proceed as scheduled with the entirety of its development plan. Moreover, there are opportunities to enhance the environment as a corollary to the development plan.

The actions recommended herein can be integrated into the basic O.M.V.S. development plan which schedules activities and projects in the Senegal River Basin over the next 50 years; during which time the population will nearly quadruple in size.

If properly managed, the Senegal River Basin can become a model, demonstrating the effects of sound planning and development on integrated water and land management practices. On the other hand, if improperly managed, the proposed developments will provide further evidence of man's overuse of his environment and its relationship to encroaching desertification.

The three types of actions described in this report are as follows:

- Recommendations to enhance beneficial environmental impacts
- Recommendations to mitigate adverse environmental impacts
- Recommendations to create or strengthen public institutions to carry out environmental actions within the context of the structures of O.M.V.S. and Member States.

In turn, these recommended actions fall into two broad categories:

- Recommendations for basin-wide actions
- Recommendations for development-related impacts

A diagram showing the scope of the recommendations is presented on the following page.

The legal authority for O.M.V.S. to carry out riverine development is established by binding covenants enacted by the Conference of Heads of State and Governments. Acting in unanimity, the conference can alter the extent of the organization's authority ("La convention portant creation de l'Organisation pour la Mise en Valeur du Fleuve Senegal", Article 17).

At present, the authority of O.M.V.S. is limited by covenant to specific common works and general coordinating functions ("Convention relative au statut juridique des ouvrage communs" December 21, 1978). Specifically, O.M.V.S. is now responsible for:

- Construction of water regulation facilities, including the financing and construction of the Diama and Manantali dams, the improvement of the irrigation canals and the operation of these common facilities;
- Protection of the rights of the three Member States in the future use of the riverine and estuarine resources;
- Coordination or harmonization of further exploitation of the river by the Member States.

Organizationally, O.M.V.S. has the potential for both increased powers in the River Basin and increased implementation responsibilities. The necessity of increasing the authority of O.M.V.S. for efficient Basin management was foreseen in structuring the organization's decision-making processes to allow for gradual expansion of responsibilities as developments are required.

ENVIRONMENTAL ACTION PLAN FOR THE SENEGAL RIVER BASIN

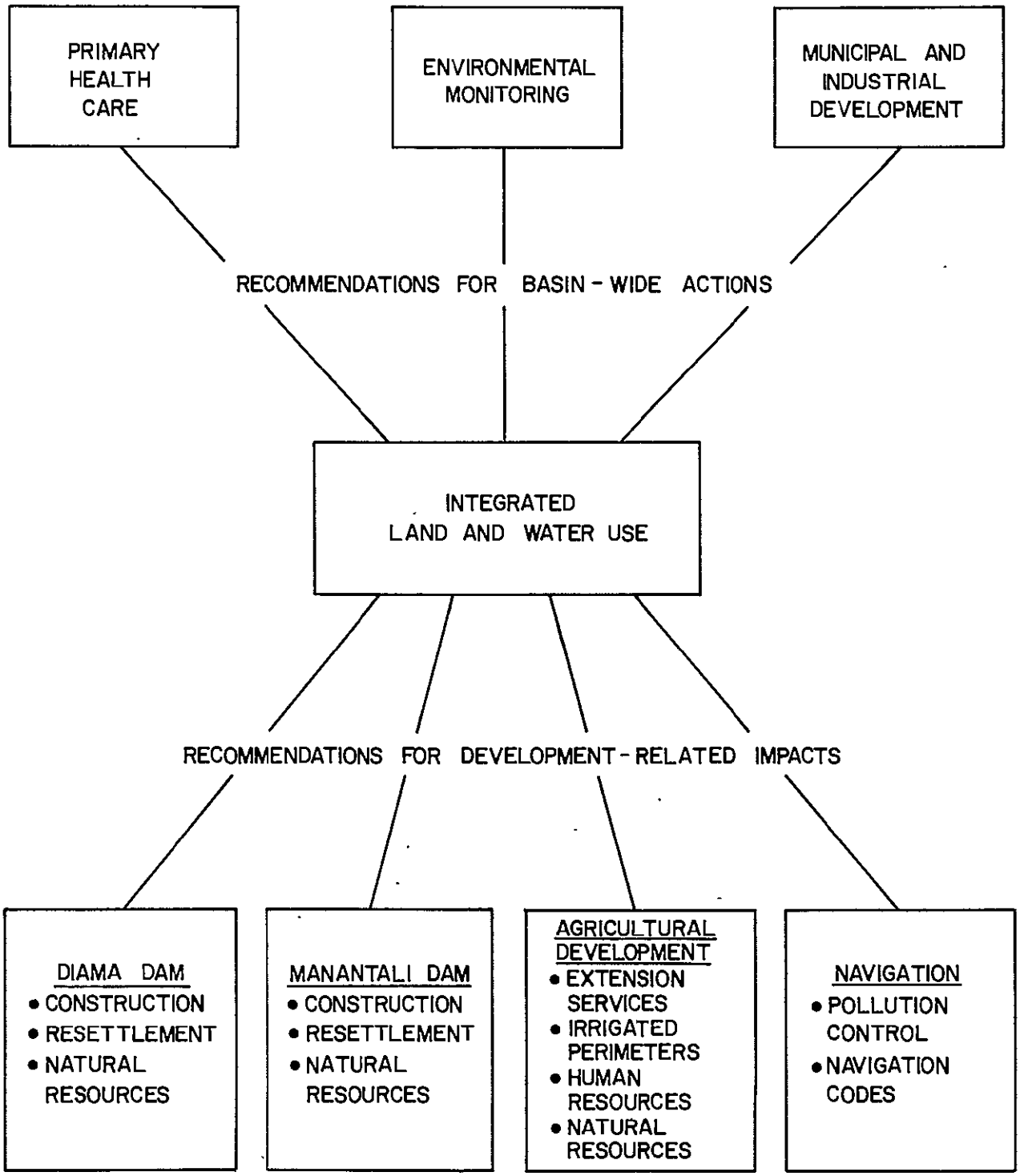


FIGURE 3

There are three tiers of decisional authority within O.M.V.S.

- The Conference of Heads of State and Governments is the policymaking body of O.M.V.S., deciding questions of economic policy and the extent of the organization's authority. Its agreements are binding on all three governments since unanimity in decisions is required. Agreements that conflict with existing national legislation take legal precedence over those laws. These national laws would have to be rewritten to harmonize with such O.M.V.S. covenants.

- The Council of Ministers of O.M.V.S. has the responsibility for defining priorities for common development projects. It can authorize projects, allocate costs of those projects to the Member States, and negotiate and accept loans and grants. Its decisions are binding on the Member States, within the directives agreed upon by the Conference of Heads of State and Governments.

- The High Commission is charged with preparation and implementation of projects to be undertaken by O.M.V.S. or cooperatively by the individual Member States. That is, it identifies projects necessary for the successful fulfillment of the broad O.M.V.S. goals as they become necessary or as complementary projects seem justified. It therefore concerns itself with the gathering of data concerning the River Basin; the preparation of integrated studies and project proposals; and the direction and coordination of project implementation by its subdivisions that include, among others, a Directorate for Regional Infrastructure and a Directorate for Regional Planning and Coordination.

Many of the recommendations of this assessment concerning environmental impacts are necessarily regional in scope, as are the impacts themselves. A broad choice is posed throughout these recommendations as to whether responses to impacts should be nationally implemented and coordinated by O.M.V.S. or implemented directly by O.M.V.S. The choice is, of course, in the domain of the Member States. These plans of actions often clearly favor one choice over another on the basis of efficiency and effectiveness, usually favoring an

institutional approach that permits environmental actions more appropriate to the regional nature of the problems.

O.M.V.S. potentially has the authority to regionalize approaches to adverse environmental impacts. A variety of avenues is open either to harmonize existing laws under national jurisdiction or to integrate enforcement capacities for certain problems under O.M.V.S. Similar options exist for the implementation of projects that will have environmental effects, such as the establishment of national standards for perimeter irrigation practices.

These potentials must be kept in mind when examining the proposed environmental action plans. The O.M.V.S. structure and willingness of the Member States to harmonize their development efforts offer a unique opportunity for multi-use development of the Basin that can enhance rather than weaken the resource base of the entire region.

The scheduling and programming presented in this section is based upon the assumption that construction of the Diama and Manantali dams will be completed by 1986. Additionally, major navigational activity in the Senegal River Basin is planned for 1986. This study also accepts the most realistic rate of development for the irrigated perimeters, based upon Groupment Manantali estimates, as 5000 hectares per year over the next 50 years.

Based upon these assumptions, various projects, studies or actions recommended by this environmental assessment should begin immediately (1980-81) or are in turn tied to these immediate actions. Other activities need to be implemented at some period, prior to, during or after the various phases of development. Because it is realized that the actual completion of the developmental phases may vary from the proposed completion dates, the year 1986 may be considered as year zero. Then, with the exception of projects which should begin immediately, any recommendation can be scheduled by its need to be completed so many years before or after the actual termination date of a developmental phase. Information for the programming of recommended activities will be found at the end of each action plan. Each activity is presented as a numbered task corresponding to the task descriptions contained in the plan of action flow charts.

INTEGRATED LAND USE PLANNING

Land and associated vegetation are the most threatened resources in the Senegal River Basin. Large portions of the Senegal River Valley downstream of Bakel have experienced a gradual depletion of vegetation during the past few decades from overgrazing by livestock, man-made fires for generation of fertilizer and the destruction of forests for charcoal and firewood. Removal of this protective cover in combination with regional climatic conditions, particularly drought, has hastened desertification.

Encroachment of desertification in the Senegal River Basin as the result of man's activities, his livestock and climate.

Land use planning should begin immediately to improve the already degraded state of the terrestrial environment existing over widespread areas of the Basin, and to minimize expected user conflicts, especially along the River's edge between Bakel and St.-Louis. Disputes will arise between urban

and industrial planners who wish to convert this land into cities and towns, agricultural interests who see the opportunity to develop irrigated perimeters and environmentalists who wish to see this land preserved in its natural state to safeguard wildlife. Proper land use planning will improve the quality of life for man and animal, and assure that maximum benefits are derived from these resources. Land use planning must integrate recommendations relating to environmental actions for agriculture, municipal and industrial development, the Diama dam and the Manantali dam. Land use planning should include:

- Basin-wide land use management guidelines including pollution standards, codes for exploitation of natural resources and a wildlife conservation code;

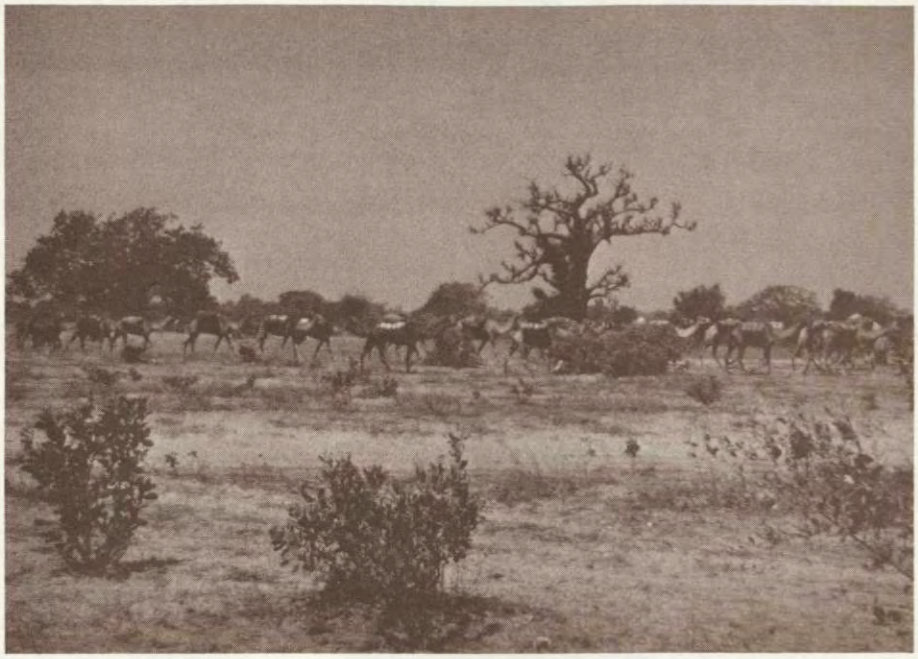
- A projection of land use needs for:

  - Rural and urban residential,
  - Commercial,
  - Industry: manufacturing and mining,
  - Agriculture: irrigated and traditional types,
  - Livestock: open range and forage production,
  - Forestry: production and preservation zones,
  - Wildlife preservation;

- A Master Land Use Plan governing allocation of lands for particular uses and the conditions for exploitation;

The Master Land Use Plan should contain actions to:

- Alleviate stress of overgrazed range lands by allowing herders an opportunity to become integrated into activities associated with irrigated perimeters;



The nomadic lifestyle of Basin residents may be affected by development.

- Regulate use of dry and wet season pasturage outside perimeters;
- Regulate and improve traditional farming practices;
- Protect and enlarge existing forests, and wildlife preserves;
- Encourage reforestation in association with irrigated perimeters;
- Harmonize laws between the Member States concerning redistribution of land and land tenure.

To implement the above activities, other volumes of this Report provide baseline data needed for proper decision-making. However, there is a need for additional inventories and research, including classification of land by

suitability for specific uses. Areas such as savannah grazing ranges and forest zones that are most in danger of degradation should be immediately identified. Additional inventories of soil types in selected areas are needed to assess their suitability for agricultural use considering drainage capacity and salinization. Herbacious and wooded zones must be inventoried as to their suitability for open and restricted livestock grazing. Zones unsuitable for agricultural or pastoral use should be identified for residential or industrial use. Basic assumptions regarding the limitations for use of these zones must be specified; such as, livestock carrying capacities, broad definition of crops suitable for an area, suitability of land for use under drought conditions, and the approximate hectarage available for each type of use.

Special attention should also be given to monitoring the population dynamics of the Basin. During the initial years of O.M.V.S. development, there will be considerable geographic movements of people and shifts from one employment sector to another. The findings from the socioeconomic volume of this Report and reports by others point to the necessity of detailed plans regarding resettlement, provision of services and land tenure patterns. All of these issues should be dealt with in the development of the Master Land Use Plan which should be given a high priority. Because these types of studies require detailed maps, work should be coordinated with the O.M.V.S. mapping program.

The High Commission should charge the O.M.V.S. Directorate for Regional Planning and Coordination with providing data and technical expertise to its Member States in regionally coordinating the development of an overall land use plan and integrated resource management program. Most importantly, O.M.V.S. will have the role of demonstrating that the three Member States cannot continue uncoordinated usage of their joint natural resources without jeopardizing the future of the region.

INTEGRATED WATER USE PLANNING

Presently there is great concern for water rights within the Senegal River Basin. As the Basin's population expands, municipal and industrial development occurs and approximately 5000 hectares of additional land are irrigated each year, there will be an increasing need to allocate and distribute water within the Basin, especially downstream of Bakel. Additionally, there will be a continued demand from areas outside the Basin, such as Dakar, which draws its potable water from Lac de Guiers. Beyond 2028 or even sooner, if a severe drought were to arise, water will be subject to user conflicts.

- By 2028, urban and industrial development will require approximately one percent of the yearly flow past Bakel. Potable water will be required by the rapidly expanding urban areas. Process waters will be used for industrial activities such as tanning hides and canning vegetables.

- By 2028, intensive irrigated agriculture will use approximately 50 percent of the yearly flow past Bakel.

- Navigation is projected to employ 20 percent of the total flow for transport of goods up and down the river.

- Environmental considerations will require water to assure adequate flooding in the promotion of a viable fishery and in assuring suitable quantities of wetland habitat necessary for migratory fowl that rely on the Basin as a wintering ground, and other aquatic animals, such as the Senegal River Manatee and Nile Crocodile.

Because budgeting of water for these purposes may become extremely critical, a Water Use Master Plan for the Basin should be developed and carried out by the Permanent Committee on Water Use and the O.M.V.S. Council of Ministers. Water use planning should include:

- Broad guidelines for the maintenance of surface and groundwater quality. These guidelines should be taken under consideration by Member States in the promulgation of national codes and regulations. Member States may also wish to establish standards for stream quality and discharge of municipal and industrial wastewater effluents, as well as for return flows from irrigated perimeters. Specific recommendations relating to the above are to be found in the Environmental Monitoring and Pollution Control Plan of Action.

- Nationally projected demands for water use by each sector, such as agriculture, industry, municipalities, navigation, and forestry.

- Continuing modeling and studies of the effects of flood control on groundwater recharge as well as the potential for the various aquifers to supplement surface waters for municipal/industrial and agricultural uses.

- A synthesis of national water demands and a Basin-wide allocation schedule indicating amounts of water to be set aside for each use in each country.

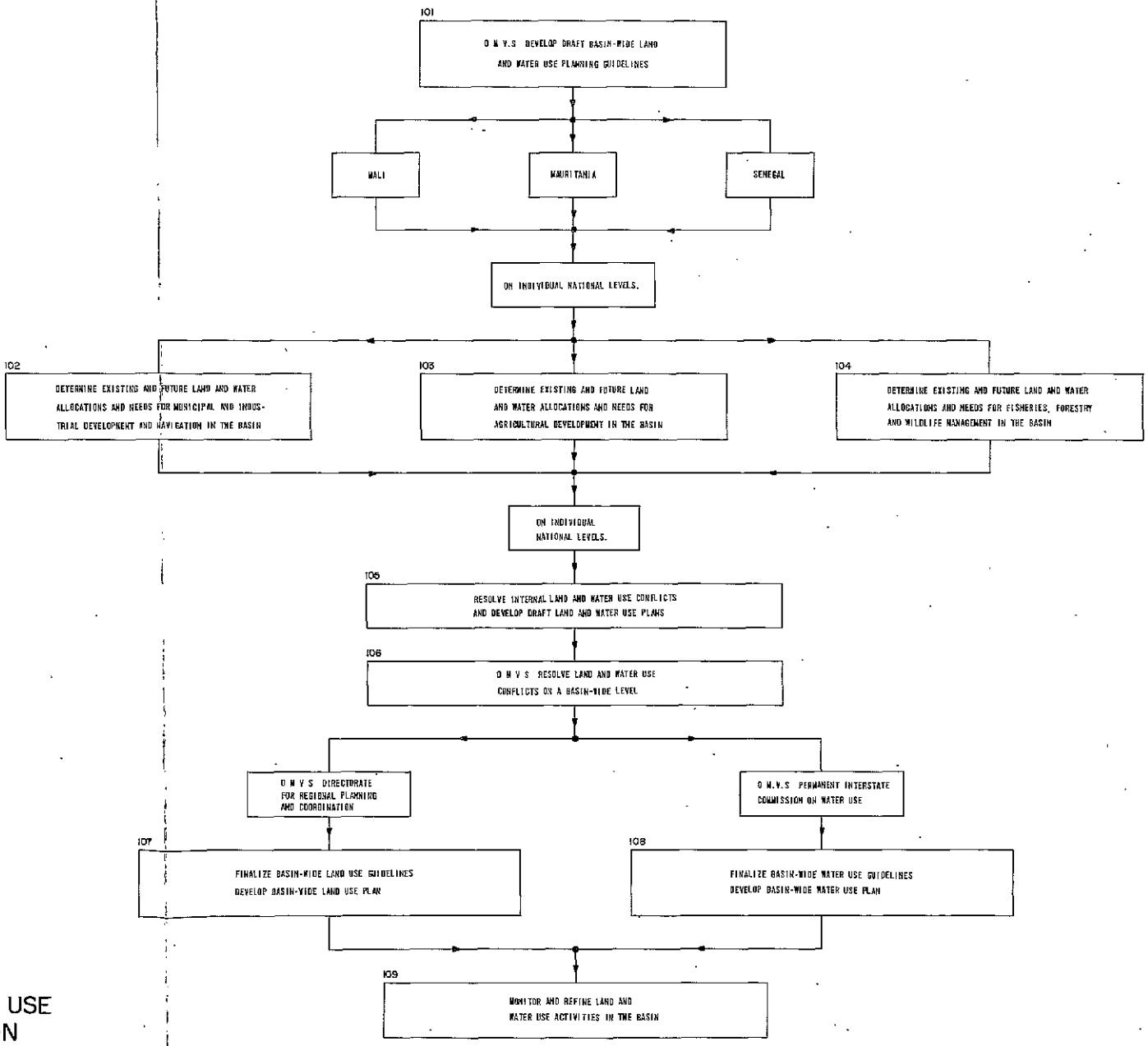
- Establishment of a set of water use priorities for the Basin based on the development objectives of each country. The quantity of water available is fixed by natural conditions. Choices as to use must be made between human consumption, irrigated agriculture, fisheries, wildlife and forestry resources, industrial use and navigation.

- Special rules for allocation of water under drought conditions. At such times, normal allocation rules will not be appropriate.

- Ancillary planning for construction needed to actually make use of the impounded water. Plans should be initiated to construct potable water facilities for enlarged populations. Provision must be made to supply irrigated perimeters with the means to regulate and measure the draw-off of water.

The O.M.V.S. is given broad powers to make recommendations to assure an equitable and efficient use of the Senegal River and its tributaries. The Council of Ministers of the O.M.V.S. is endowed with the authority of decision-making. It should devise the recommended water allocation formula and enact it into treaty form.

All technical recommendations come from the Permanent Interstate Commission on Water Use, which reports directly to the O.M.V.S. High Commission. The High Commission, in turn, transmits appropriate findings and recommendations to the Council of Ministers for action. The Permanent Commission on Water Use is legally charged with the creation of a formula for the equitable distribution of water from the Senegal River and review and appraisal of all requests for water use that would alter the flow regime or affect water quality.



INTEGRATED
LAND AND WATER USE
PLAN OF ACTION

FIGURE 4

PROGRAMMATION DES ACTIVITES CONCERNANT L'UTILISATION INTEGREE DES EAUX ET DES TERRES DANS LE BASSIN DU FLEUVE SENEGAL.

PROGRAM SCHEDULING ASSOCIATED WITH INTEGRATED LAND AND WATER USE IN THE SENEGAL RIVER BASIN

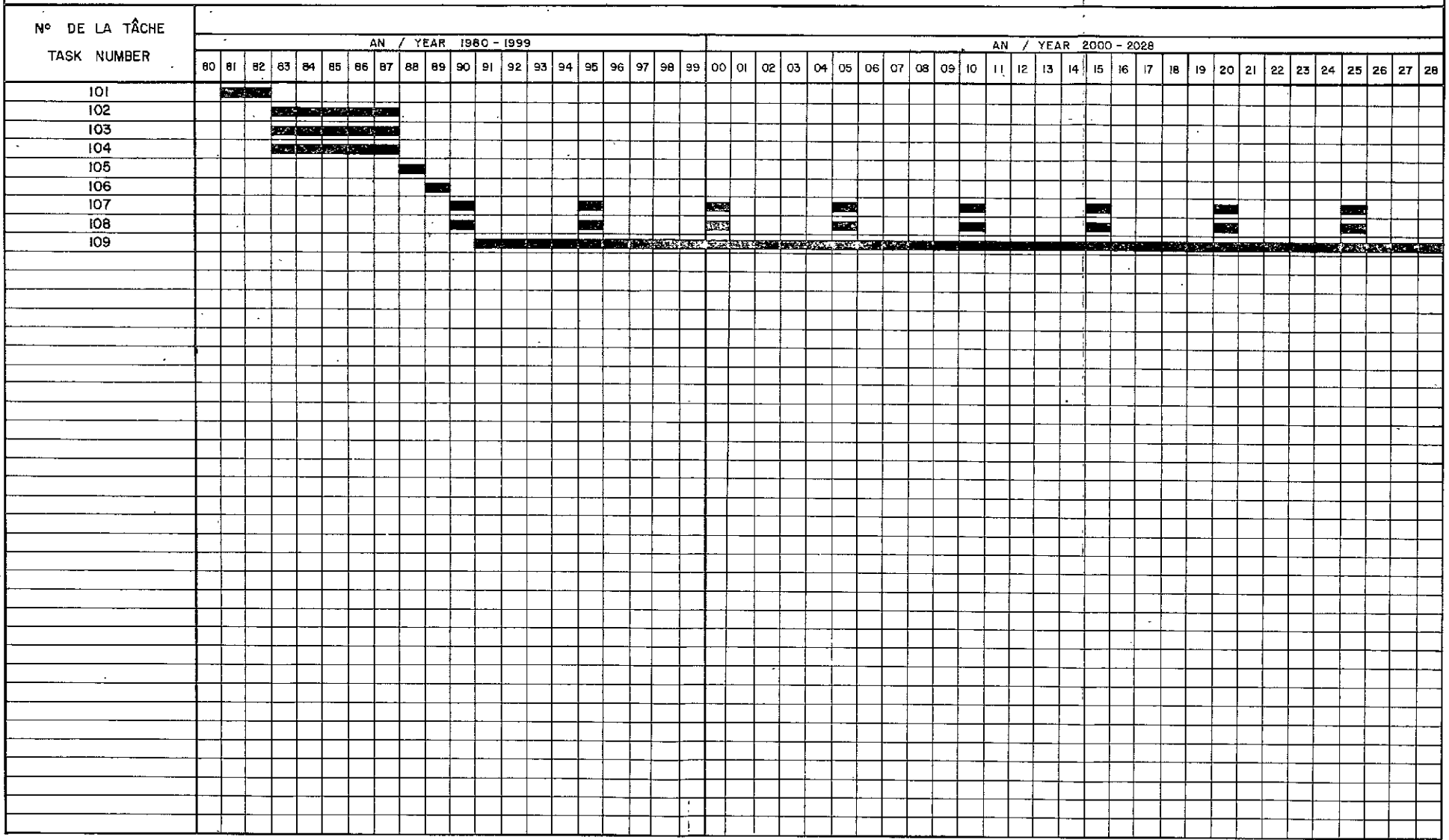


FIGURE 5

PRIMARY HEALTH CARE AND HEALTH MONITORING

The health care systems of the three Member States share many basic characteristics with those of other developing countries. They are understaffed, seriously undersupplied and suffer from a weak administrative support structure. The major deficiency is the lack of an effective health care infrastructure at the community level. The development of a primary health care service for the regions of the Senegal River Basin would serve as the principal mitigating measure against adverse health impacts of the Basin development program.

Environmental Assessment Study Team conducting survey to determine the needs of primary health care in the Basin.

Primary Health Care

Without a health infrastructure, programs aimed at ameliorating, controlling or eradicating diseases, with rare exception such as smallpox, achieve at best, only temporary or partial success. Even then, it is at a cost that is unrealistic, if not prohibitive.

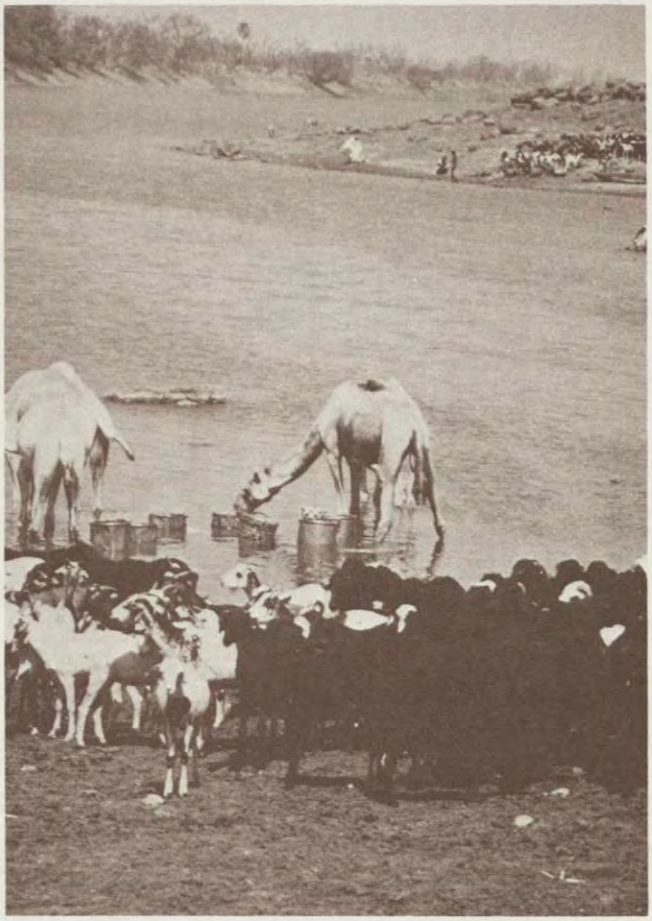
It is intended that the health program proposed herein would not make excessive demands on the national health budgets and would provide more effective services at the community level. It could be financed mainly by the community served and would provide simple curative and preventive health care to all community members. This approach is currently being put into practice in many countries of the developing world, including Senegal (The Sine-Saloum) and Mali (The Yelimane-Koro pilot project). The World Health Organization is promoting this approach for developing countries as the solution that makes the best use of existing human and financial resources.

It is felt that health care systems requiring small payments can succeed, even where free public medical care has been national policy. Villagers traditionally have to pay for medical service, whether it has come from the local pharmacy, the dispensary nurse, itinerant medicine sellers, or traditional healers. Thus, paying for a primary health care unit should not require a great social adjustment. Also, given the current strength of the national economies involved, the governments cannot support an effective health care system without direct support from the people served by it.

This program is readily adaptable to the existing health services of the O.M.V.S. Member States. It will include the addition of a new level of health care personnel - the village health worker. The health worker would participate at the community level and would function below the levels of the regional health post personnel, as follows:

- Health Hut - The basic component of the primary health care system is the village health hut. Each health hut would serve 2000 to 4000 people, about 8 to 10 villages, and would be staffed by two village health workers and one village sanitarian. The staff would deal with:

  - personal, family and community health and sanitation,
  - basic curative services such as diagnosis, first aid, and dispensing medicine,
  - preventive services such as health education, and environmental sanitation.



Animals watering, people bathing, washing clothes and obtaining drinking water out of the Senegal River. One reason sanitation education is needed in the Basin.

The health workers would be responsible for basic first aid, disease diagnosis and dispensing of medicine. The sanitarian would be responsible for encouraging the development of sanitary practices through activities such as instruction and demonstration of personal hygiene, pre- and postnatal care, proper handling and preparation of food, proper construction and location of privies and wells. These personnel would aid in conducting periodic sociological studies needed to adapt the sanitation and health care programs to local culture and traditions.

- Health Post - Health complications, injuries and illnesses which exceed the diagnostic or treatment capabilities of the health hut would be referred to a regional health post (dispensary) serving

approximately 10 health huts. Each health post would be staffed by a nurse, midwife, sanitation agent and an orderly. Among other duties, they would provide training to health hut personnel, distribute drugs to health huts and refer serious health cases to national health centers and hospitals for advanced treatment. Responsibility for professional activities would be with the Ministries of Health of the Member States, acting through the directors of the health posts.

The principal costs of the primary health care program would be salaries and drugs. Because of the danger of illicit drug trafficking, it is recommended that an inventory control program be established to carefully monitor the distribution and supply of drugs.

The suggested role of the O.M.V.S. will be one of coordination, securing financial and technical support from international sources, and providing a public health information center for the Basin. Implementation of primary health care should be the responsibility of the health ministries of Senegal, Mauritania and Mali.

The health ministries and O.M.V.S. must be informed about all health care activities because of the need to coordinate the health care system and assess its effectiveness. Periodic assessments of public health conditions would also be useful. The presentation of annual reports by health post personnel could provide this type of information.

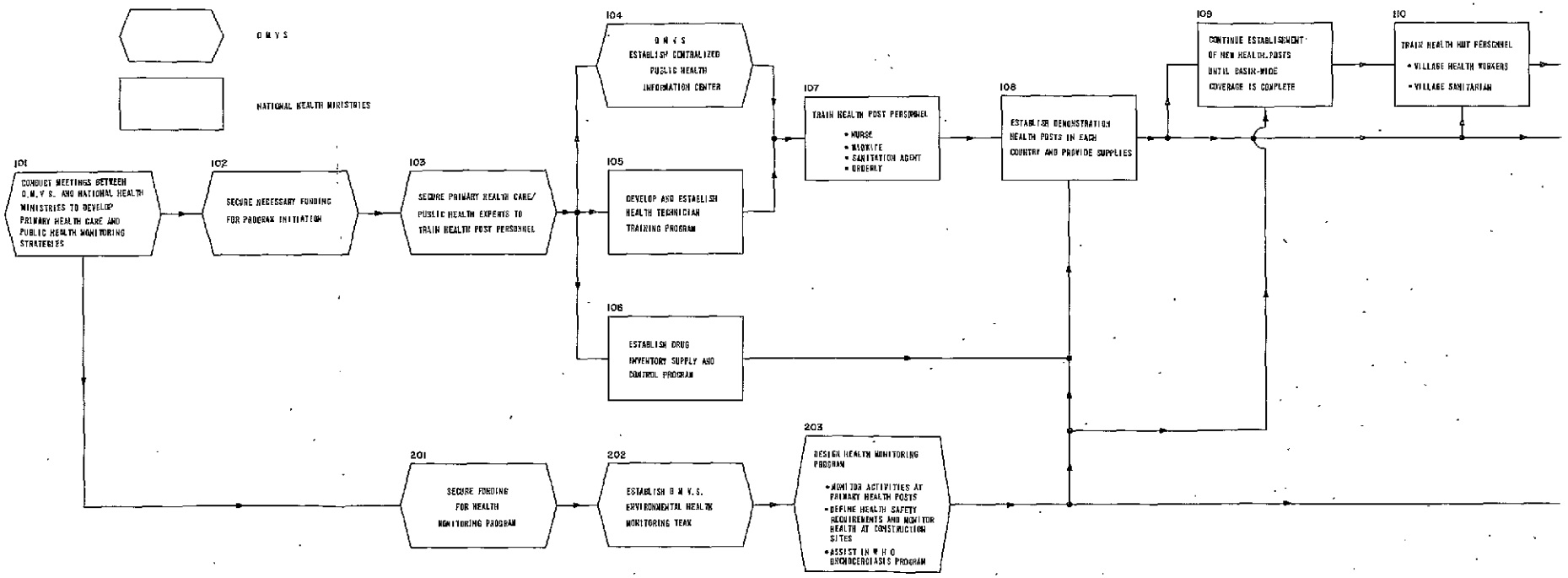
Health Monitoring

It is proposed that O.M.V.S. establish a health monitoring program that would maintain surveillance for changes in disease patterns in the Basin. Senior program officials would serve as an advisory group to the Member States for health problems in the Basin that are of common interest.

To make this program effective, arrangements must be provided to:

- Inspect activities at primary health care units;
- Conduct periodic sociological studies to gauge the adaptation of the primary health program to local culture and traditions;
- Refine activities at primary health care units;
- Develop a system for detecting significant changes in disease patterns in the Basin;
- Monitor disease infection rates and transmission potential throughout the Basin based on statistics provided by the health care facilities;
- Report significant changes in disease patterns to the national health ministries;
- Monitor nutrition;
- Assist in the recommended World Health Organization onchocerciasis control program;
- Assist O.M.V.S. in defining health protection requirements at major construction sites and assure that these requirements are fulfilled at these sites;
- Arrange for special studies that may be indicated by monitoring results.

Because of their close ties, primary health care and health monitoring programs should be conceptualized as one planning effort by O.M.V.S. and the Member States. The monitoring effort should involve an environmental monitoring team of public health experts within O.M.V.S. who will be represented by and cover each of the three Member States, maintaining permanent contact with the national health agencies. Planning activities should begin immediately.



PRIMARY HEALTH CARE AND HEALTH MONITORING PLAN OF ACTION

FIGURE 6

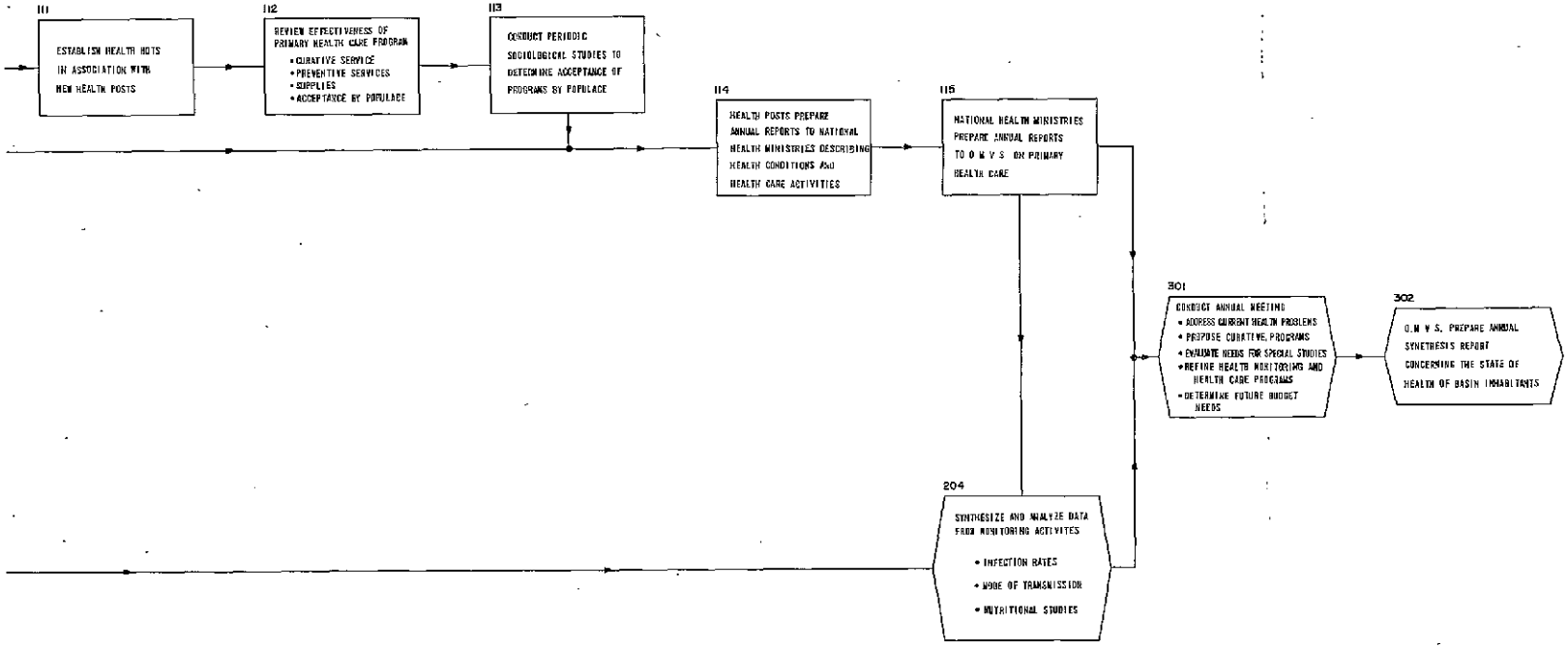


FIGURE 6 (CONTINUED)

PROGRAMMATION DES ACTIVITES CONCERNANT LES SOINS DE BASE DANS LE BASSIN DU FLEUVE SENEGAL

PROGRAM SCHEDULING ASSOCIATED WITH PRIMARY HEALTH CARE IN THE SENEGAL RIVER BASIN

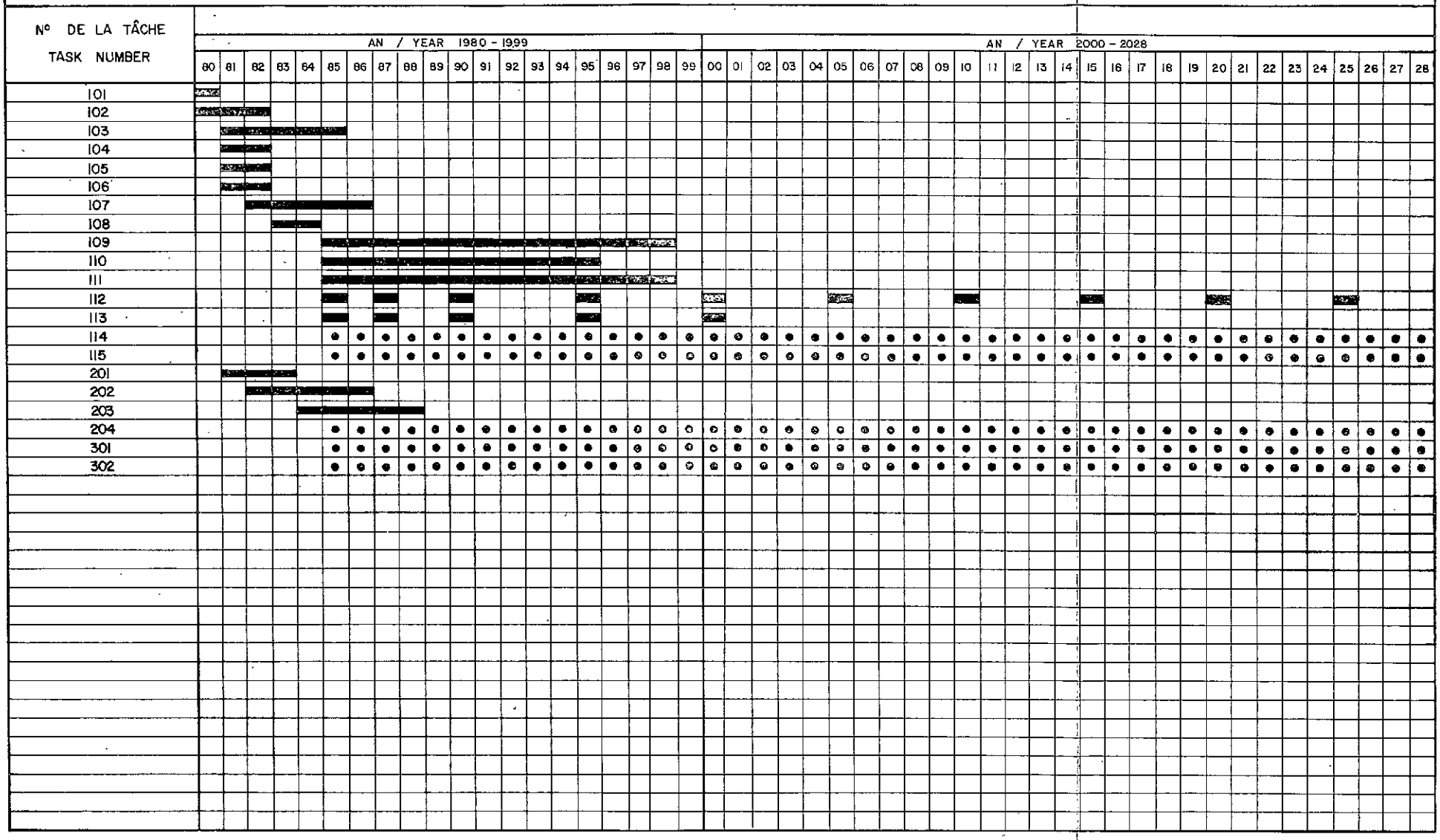


FIGURE 7

ENVIRONMENTAL MONITORING AND POLLUTION CONTROL

Monitoring of the Senegal River Basin must involve periodic inspections and analysis of factors indicative of environmental quality. This assessment has demonstrated that proposed developments may have profound effects on the environmental setting of the Senegal River Basin. The extent to which these predictions occur can be verified only by monitoring. Compilation of these data over a period of time will permit assessment of environmental quality trends and analysis of impacts brought about by proposed developments. Mitigative measures can be taken before adverse impacts on the environment become irreversible. This baseline information will also provide useful data for updating and refining the salinity, dissolved oxygen, and inundation models used during this Environmental Assessment. This program will provide data for use in administering the Master Land and Water Use Plans for the Senegal River Basin.

Environmental Monitoring System

The technical components of the proposed monitoring program should emphasize the water resource parameters identified on Table 1 that respond to environmental quality changes.

Areas of monitoring should include the following:

- Climate - Monitoring of climatic variables should be limited to precipitation, temperature, humidity, wind and evaporation. The recommended program should include upgrading and continuation of existing climatic station operations and the development of new stations.

- Streamflow - A moderate extension of the existing network is desirable. New observation stations are recommended at the Manantali and Diama dams, as well as at the inlets to the Taouey Canal, Lac R'Kiz and the Aftout es Sahel. Additionally, water withdrawals from the river for agricultural,

Table 1

PROPOSED ENVIRONMENTAL MONITORING PROGRAM

Type of Monitoring	What to Monitor	Where to Monitor	When and How Often to Monitor
Climate	Precipitation, air temperature, relative and actual humidity, wind direction and speed Evaporation.	Mali: Kayes, Kenieba, Kita, Manantali, Nioro du Sahel, Mauritania: Boghe, Kiffa, Rosso. Senegal: Linguere, Matam, Saint-Louis. Evaporation at Kayes, Matam, & Rosso only.	Twice daily at noon and 8:00 p.m.
Surface Water Levels/ Streamflows	Water levels that can be converted to flows using valid stage-discharge relationship.	Existing gaging stations: Mali: Bafing - Makana, Dakka - Saidou, Dibia, Fadougou, Galougo, Gouina, Gourbassi, Kayes, Oualia, Soukoutali - Manantali, Toukoto. Mauritania: Boghe, Kaedi, Rosso. Senegal: Bakel, Dagana Guede, Kidira, Madina, Matam, N'Goui, Oudounde, Podor, Richard Toll, Saint-Louis, Salde.	Same procedure as is now being used at existing stations.

Table 1 (Cont'd.)

PROPOSED ENVIRONMENTAL MONITORING PROGRAM

Type of Monitoring	What to Monitor	Where to Monitor	When and How Often to Monitor
Surface Water Levels/ Streamflows (cont'd.)		New stations: -channels to Lac de Guiers, Lac R'Kiz and Aftout es Sahel -downstream from the Diama dam site	
	Water levels only	Lac de Guiers, Lac R'Kiz, and at the spillways of the Diama and Manantali reservoirs.	
	Withdrawals at irrigated perimeters, municipalities and industries.	Flows pumped at these locations.	
Surface Water Quality	Constituents: 1) Dissolved Oxygen 2) Temperature 3) pH, alkalinity 4) Salinity 5) Suspended Solids	Upstream of Manantali Reservoir but downstream of Bale - Bafing confluence: 1, 2, 3, 5, 6*	Twice a year during April/May and October
	6) Biochemical oxygen demand (Five-day BOD) 7) Fecal coliform counts	Within Manantali Reservoir at dam and prescribed location in middle of reservoir: 1 and 2* at various depths 3, 5, 6* at one meter from surface and one meter from bottom.	Twice a year during April/May and October
		Just downstream of Manantali Reservoir, In Bafing River at confluence with Bakoye, In Bakoye at confluence with Bafing, In Faleme at confluence with Senegal River, In Senegal River at confluence with Faleme River, in the Senegal River less than 1 km. downstream of Matam, Podor, Richard Toll and in the Doue Marigot less than 1 km. downstream of N'Goui: 1, 2, 3, 5, 6*	Twice a year during April/May and October

*Correspond to water quality parameters numbered in the "What to Monitor" column.

Table 1 (Cont'd.)

PROPOSED ENVIRONMENTAL MONITORING PROGRAM

Type of Monitoring	What to Monitor	Where to Monitor	When and How Often to Monitor
Surface Water Quality (cont'd.)		Senegal River downstream of Kayes, Bakel, Matam, Kaedi, Podor, Richard Toll-Rosso: 1, 2, 6 and 7* every 500 meters downstream of municipalities; 1 and 2* at various depths; 6 and 7* at mid-depth.	Once per year during April/May
		Less than 1 km upstream and downstream of Diama, Saint-Louis, entry channel and natural mouth: 1, 2, 4, 5 and 6*	Twice a year during April/May and October
		Two locations each at Lac de Guiers & Lac R'Kiz: 1 through 6*	Twice a year during April/May and October
		Waters entering and exiting all water treatment plants: 7*	
	Special tests to be performed once in five years at locations to be decided upon by the monitoring team: Total phosphorus Total Kjeldahl nitrogen Nitrates Algae populations - counts & diversity	At locations selected by monitoring personnel.	
Groundwater Resources	Well physical characteristics,	Special one-time survey of physical and flow characteristics of each known water supply well in the basin.	

* Correspond to water quality parameters numbered in the "What to Monitor" column on the previous page.

Table 1 (Cont'd.)

PROPOSED ENVIRONMENTAL MONITORING PROGRAM

Type of Monitoring	What to Monitor	Where to Monitor	When and How Often to Monitor
	Well water levels, aquifer water levels, Flows available at wells, Well water quality & Aquifer water quality, (pH, alkalinity, chemical oxygen demand, fecal coliform counts, salinity)	Monitor physical characteristics, well water levels and water quality at approx. 40 wells of different types that extract water from the various aquifers and are located at different distances from the river (quantity and quality monitoring). Five of these wells recommended for water quality monitoring should be located downstream of Rosso. Salinity only recommended to be measured in delta wells. Five prescribed sites near perimeters and urban areas and five in open areas for monitoring aquifer water quality are recommended.	Dry-season and wet-season survey once every five years, otherwise One time per year during April/May (in conjunction with surface water quality monitoring)
Fish Resources	Yields and diversity of fish populations and the significance of fish as a food source.	At Manantali and Diama impoundments and the estuary downstream of Diama.	One survey every year
Aquatic Vegetation	Approximate numbers and types of algae and other squatic plants.	At the Manantali and Diama Impoundments, Lac de Guiers, Lac R'Kiz, and Aftout es Sahel and at the irrigation and drainage canals at selected irrigated perimeters.	One survey every two years during April/May Communication with villagers is also recommended.
Streambed and river bank erosion	Visual qualitative information about sediment deposits in the river and at river bank cave-ins. Information about changes in the configuration of the future navigation channel.	All along the Senegal River between Kayes and Saint-Louis (by boat)	One time every two years during April/May (during years when fish and aquatic vegetation are not monitored) Communication with navigators is also recommended.

Table 1 (Cont'd.)

PROPOSED ENVIRONMENTAL MONITORING PROGRAM

Type of Monitoring	What to Monitor	Where to Monitor	When and How Often to Monitor
Ranges and Forests	Changes in the amount of land and types and density of vegetation available for grazing lands and forests.	All throughout the Senegal River Basin.	Continuous monitoring on a regional basis. Periodic aerial surveys of amounts and conditions of grasslands and forests.
Wildlife	Diversity and density of wildlife in various habitats.	Throughout the Senegal River Basin at selected sites representative of various habitats.	Continuous monitoring on a regional basis. Periodic aerial surveys of amounts and conditions of grasslands and forests.

municipal and industrial uses should be recorded. These data are essential for effective water allocation.

- Surface Water Quality - An extensive surface water quality monitoring program is suggested, because water quality is the main indicator of environmental degradation. Periodic monitoring of surface waters will permit trends in water quality to be observed and in turn to be evaluated. These data will be necessary for enforcement of water quality standards. Furthermore, water quality monitoring will permit evaluation of the aquatic ecosystem to support various levels of life.

- Groundwater Quality - Relatively little groundwater quality data is available in the Basin. Monitoring of water quality at about 40 wells representing the different aquifers should be undertaken at least once a year to observe the effects of development on groundwater quality. During one year in five, the survey should be conducted both shortly after the annual flood peak and at the end of the following dry season. Well sites should be located in both urban and rural areas. Annual sampling of the salinity in water from wells located in the Delta upstream of Diama will show the effects of continual fresh water recharge following construction of the Diama dam.

- Aquatic Biota - Monitoring of fish and aquatic vegetation will provide an additional means of illustrating the effect of the Senegal River Basin development on the aquatic ecosystem. Fish monitoring can rely mainly on observations of fish species and quantities available at markets throughout the Basin, and on interviews with artisanal fishermen. Comparison of sampling results will indicate changes in fish populations.

- Sedimentation and Erosion - Although major environmental problems are not expected to arise from the change in the Senegal River's sedimentation and erosion regimes, it is advisable to perform an inspection of the river channel and banks after each annual flood. Problem areas can be identified and measures taken to correct them.

- Land Use - The results of this effort should clearly identify land use changes and land quality. Annual monitoring of range and forest areas as well as irrigated perimeters is particularly recommended for the purpose of gauging desertification. Satellite imagery can be especially useful in the future for this monitoring program.

Environmental monitoring of the Senegal River Basin will be conducted by the various national agencies of Senegal, Mauritania and Mali or task forces provided by the Member States and coordinated by O.M.V.S. This information will allow the O.M.V.S. to fulfill its responsibility for protecting the multiple use potential of the River. It is proposed that O.M.V.S. actions related to environmental monitoring be coordinated by an Environmental Monitoring Team under the O.M.V.S. Directorate of Planning and Coordination. The recommended O.M.V.S. activities will require the full-time services of a permanent director. This person can, with a one or two-person staff, perform O.M.V.S. coordination of the environmental monitoring program.

It is recommended that experts be retained to assist the O.M.V.S. in defining the details of the monitoring program, organizational activities, establishing standards and procedures, and in supervising the phases of the field and laboratory operations. The O.M.V.S. should be responsible for funding the monitoring program. The equipment required by task forces that combine the resources of Mali, Mauritania and Senegal should be secured with

the help of the O.M.V.S. This includes establishment of mobile and stationary water quality laboratories and procurement of equipment such as boats, motors, traps, nets, vehicles, field equipment and other supplies necessary for the various levels of environmental monitoring. Revisions of monitoring and testing procedures may be required, considering the success or failure of the various monitoring techniques used. Any procedural revisions should be coordinated between O.M.V.S. and the government agencies responsible for the monitoring activity in question.

Pollution Control

The result of this Study did not reveal any significant pollution problems in the Basin. Presently the level of pollution loading discharged into the Senegal River does not approach its assimilative capacity nor are waste characteristics such that they presently cause environmental problems. As development in the Basin proceeds, the pollutant discharges will increase and unless regulated, it is possible that pollution will approach the assimilative capacity of the River, resulting in degraded conditions and violation of water quality criteria.

Presently there is little air, noise or solid waste pollution in the Basin. Over the next 50 years, as the population expands from 1.7 to 6.3 million people, and agro-industry evolves, pollution will increase. Enactment and enforcement of pollution laws before substantial development occurs would help prevent pollution problems from occurring. An effective monitoring program, as recommended by this study, is essential to provide the data necessary to recognize these conditions and to provide information necessary to enforce the proposed pollution code.

- Water Quality Code - The national ministries responsible for water quality and the O.M.V.S. Permanent Interstate Committee on Water Use should establish pollution control criteria for the Senegal River Basin by using national codes such as in Senegal and by adapting portions of codes where applicable from developed countries such as the United States and France. The Permanent Interstate

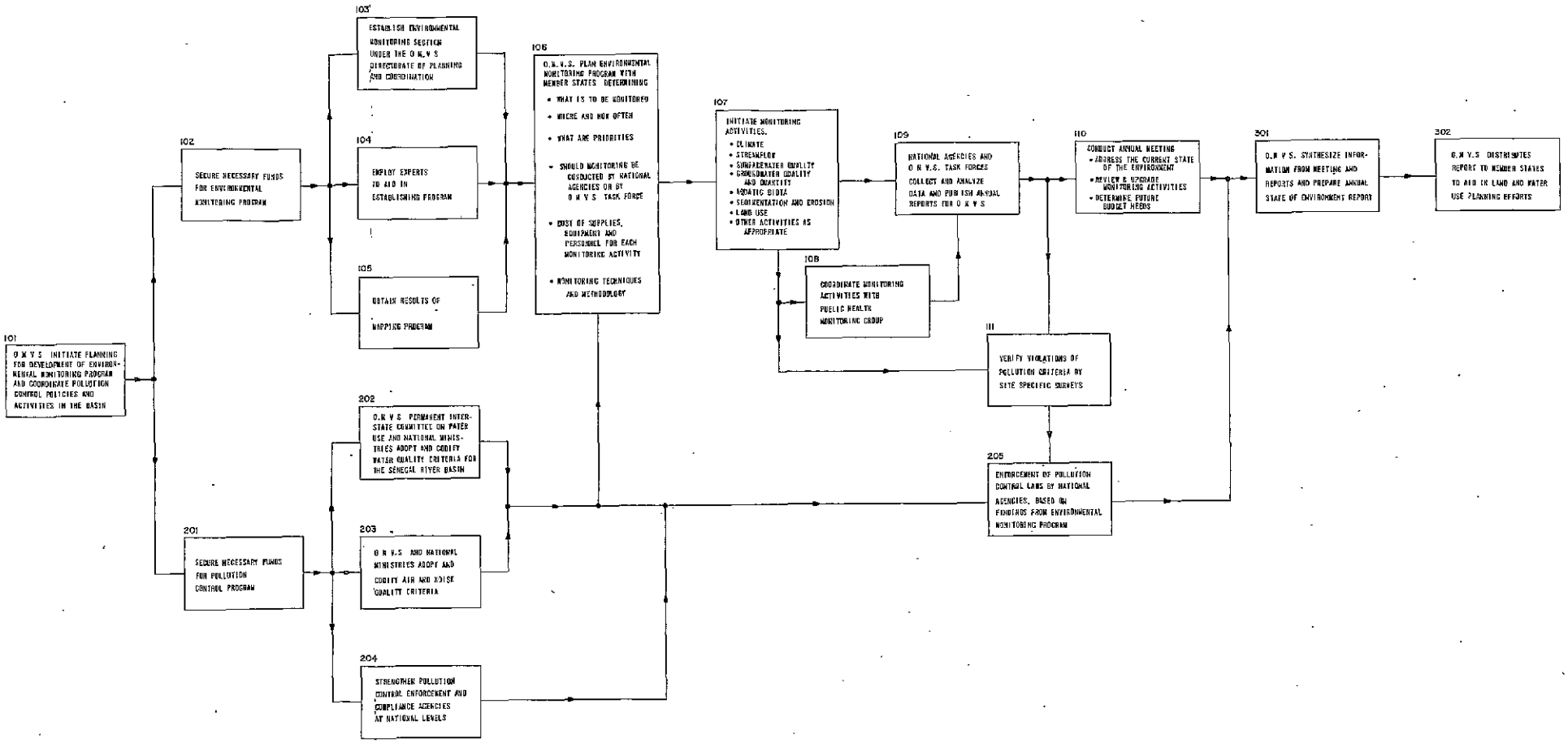
Committee on Water Use should, under existing O.M.V.S. authority, codify pollution control criteria of the Member States. Enforcement of a standardized code could be carried out by national agencies. Enactment of water quality criteria prior to the development of major facilities and urban centers can be the base for preserving quality of waters and avoiding large amounts of pollution and subsequent expensive clean-up operations.

- Air, Noise and Solid Waste Codes - Similar codes should be established by O.M.V.S. and the Member States for both air and noise pollution control in the Senegal River Basin; although the priority is not as great as for water quality codes. The O.M.V.S. could attempt to standardize these laws in Mali, Mauritania and Senegal. Enforcement could be carried out by national agencies.

- Environmental Protection Laws - Special attention should be given to harmonizing and strengthening environmental protection laws and enforcement powers in the three Member States. By mid-1980 the Senegalese Legislature will have adopted a pollution control code developed by the Ministry of Urbanism and the Environment. It will cover industrial pollution, pollution of freshwater and saltwater, air pollution and noise pollution. The present organization in Mauritania charged with environmental concerns, the Commission for the Protection of Natural Resources, has no trained staff for monitoring or administering control over other ministries concerned with the quality of the environment. Pollution control activities in Mali are essentially nonexistent.

The recommended roles of O.M.V.S. in pollution control activities are coordinating pollution control policies and actions throughout the Basin, and helping to secure needed technical and financial assistance from international sources.

The coordinating responsibilities of O.M.V.S., following identification of a pollution problem, will be directed toward assisting the Member States in resolving it in a manner that best serves the interests of the River Basin and the maintenance of environmental quality at a level commensurate with the beneficial uses being made of the resources. The compilation of monitoring activities into annual reports by the various national agencies should be followed by the synthesis of this information into an annual State of the Environment Report published by O.M.V.S. This will allow the quality of the environment in the Basin to be assessed. Pollution trends can be observed and mitigated where adverse trends are observed.

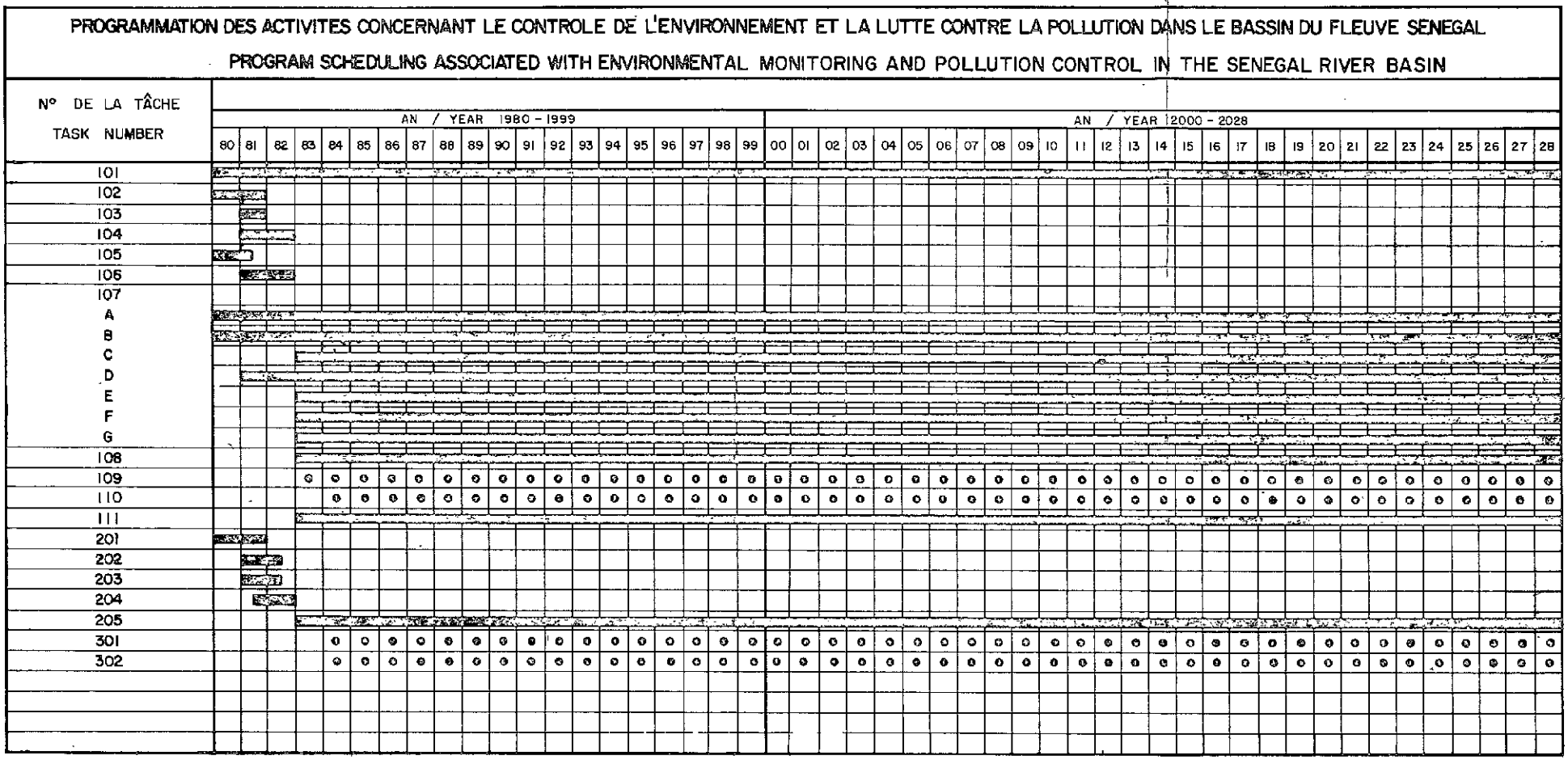


ENVIRONMENTAL MONITORING AND POLLUTION CONTROL PLAN OF ACTION

FIGURE 8

PROGRAMMATION DES ACTIVITES CONCERNANT LE CONTROLE DE L'ENVIRONNEMENT ET LA LUTTE CONTRE LA POLLUTION DANS LE BASSIN DU FLEUVE SENEGAL

PROGRAM SCHEDULING ASSOCIATED WITH ENVIRONMENTAL MONITORING AND POLLUTION CONTROL IN THE SENEGAL RIVER BASIN



A CLIMAT / CLIMATE
B DEBIT / STREAM FLOW
C QUALITE DES EAUX DE SURFACE / SURFACE WATER QUALITY
D QUALITE DES EAUX SOUTERRAINES / GROUNDWATER QUALITY
E BIOTOPE AQUATIQUE / AQUATIC BIOTA
F SEDIMENTATION ET EROSION / SEDIMENTATION AND EROSION
G L'UTILISATION DES TERRES / LAND USE

FIGURE 9

MUNICIPAL AND INDUSTRIAL DEVELOPMENT

An Urban Area Master Plan will help ease the expected growing pains that the cities in the Basin will experience in the future. The following is a brief outline of the steps required in the development of that plan:

- An Awareness Program should be developed for planning officials by O.M.V.S. to provide them with the latest information on the most recent findings from this Study such as projected population levels, water resource requirements, economic potentials and demands for services resulting from Basin development. These officials must also be made aware of the measures needed to insure that development proceeds on an environmentally sound basis, providing a sound economic base for the population, while conserving crucial natural resources.

- Develop maps of the Urban Area - Showing the following:

  - Physical limits of urban area;
  - All existing roads (paved or unpaved);
  - All existing residential establishments and associated land;
  - All existing industrial establishments and associated land;
  - All existing governmental establishments and associated land (including schools, police and administrative buildings);
  - All existing utility distribution systems (water, electricity and sewerage).

- Divide presently used and unused land within the urban areas.

- Public Utilities should keep pace with the expanding geographical and population growths of urban areas. Data and information on the present status of existing utilities including water, sewerage, solid waste disposal and electricity will be required as follows:

- Capacity;
- Consumption by class of consumer;
- Levels of service;
- Status of information services (maps, etc.);
- Condition of physical facilities;
- Financial stability;
- Upgrading or replacement needs.

- Project future populations and determine how land and utility requirements will increase as the population grows.

- Determine what and where industries and commercial business will become established in the future and how much land, and utilities each should require and when they are expected to be built. Also determine what future governmental needs will be for administrative building, schools, police, etc.

- Analyze and project urban growth and zoning. The zones should indicate land that is to be used for certain types of development, such as government and residential. Future urban population projections should be refined for each urban area and land needs should be correlated with population growth. Land should then be further subdivided to indicate which lands should be developed first.

- A Pre-Investment Study on all utilities should be initiated. This study would project future needs based on projections of population growth and density increases in urban areas, changes in per capita consumption and increases in commercial and industrial activities. Preliminary engineering studies for a staged development program should be carried out in sufficient detail to enable projections of capital and recurrent costs to be made for a period of at least 40 years.

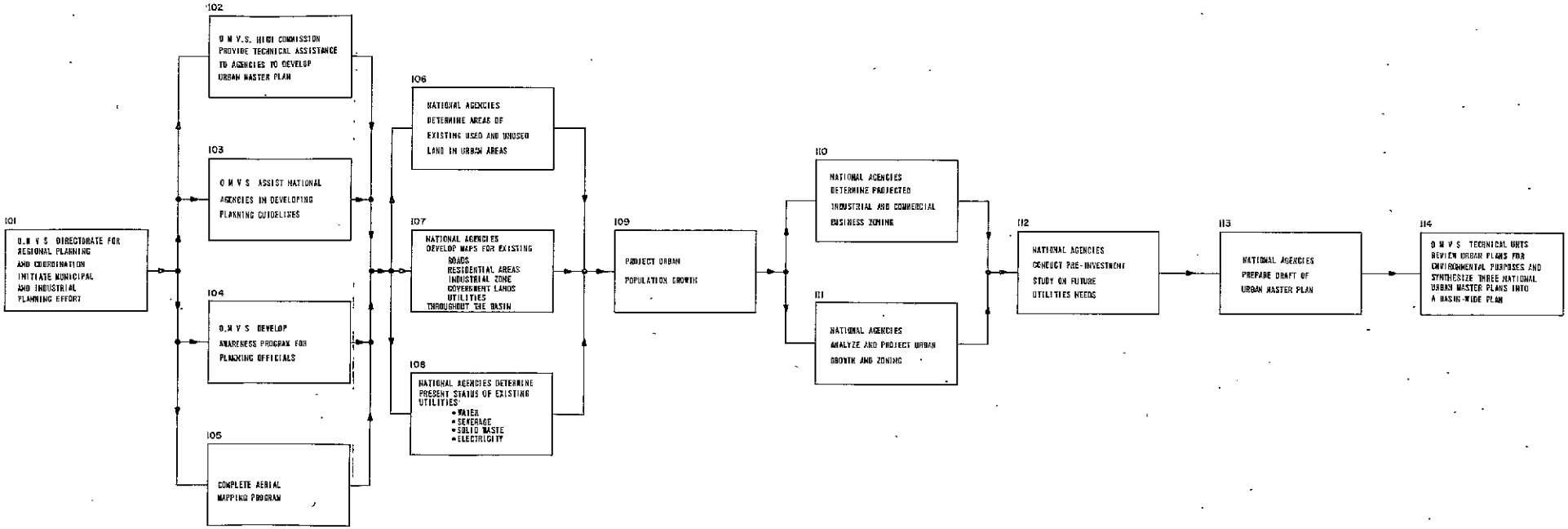
Improper solid waste disposal in St.-Louis.

Presently there is not a division within O.M.V.S. specifically charged with development of urban areas. The O.M.V.S. Directorate for Regional Planning and Coordination, however, is charged with undertaking studies for long-term development of the Senegal River Basin. This Division has the responsibility for harmonizing Member State development plans within the context of the objectives pursued by the Basin development and for studies of secondary effects of O.M.V.S. projects. As recommended in the Basin-wide Land Use Plan, this agency using available technical data on land suitability and projected land use needs, would set aside appropriate parcels of land for residential and industrial use in urban and rural areas. National land planning agencies would work with O.M.V.S. in such planning. In turn, the Master Land Use Plan would serve as a guide for future Member State development plans for zones in the Basin.

It is proposed that the O.M.V.S. High Commission provide technical assistance to regional or metropolitan land use planning agencies in carrying out detailed local master plans. At the present time each country has an

agency or agencies in charge of such planning. At the regional and local levels, planning committees will be in need of detailed planning guides outlining standards of water quality, land development, pollution control, and so on, that they will be expected to meet under the proposed codes. The O.M.V.S. should assist the national planning agencies in preparing such guidelines.

Finally, to identify Basin-wide planning activities that have potential environmentally adverse ramifications, O.M.V.S. should participate, as an observer, in the final stages of review and approval of urban and industrial projects. Urban master plans should be reviewed by technical units within O.M.V.S. to identify effects on environmentally sensitive areas such as water quality and the River regime, and the incidence of disease. This function should be a responsibility of the O.M.V.S. Directorate of Regional Planning and Coordination as proposed in the environmental monitoring section of this plan of action.



MUNICIPAL AND INDUSTRIAL DEVELOPMENT PLAN OF ACTION

FIGURE 10

PROGRAMMATION DES ACTIVITES CONCERNANT LES AMENAGEMENTS MUNICIPAUX ET INDUSTRIELS DANS LE BASSIN DU FLEUVE SENEGAL

PROGRAM SCHEDULING ASSOCIATED WITH MUNICIPAL AND INDUSTRIAL DEVELOPMENT IN THE SENEGAL RIVER BASIN

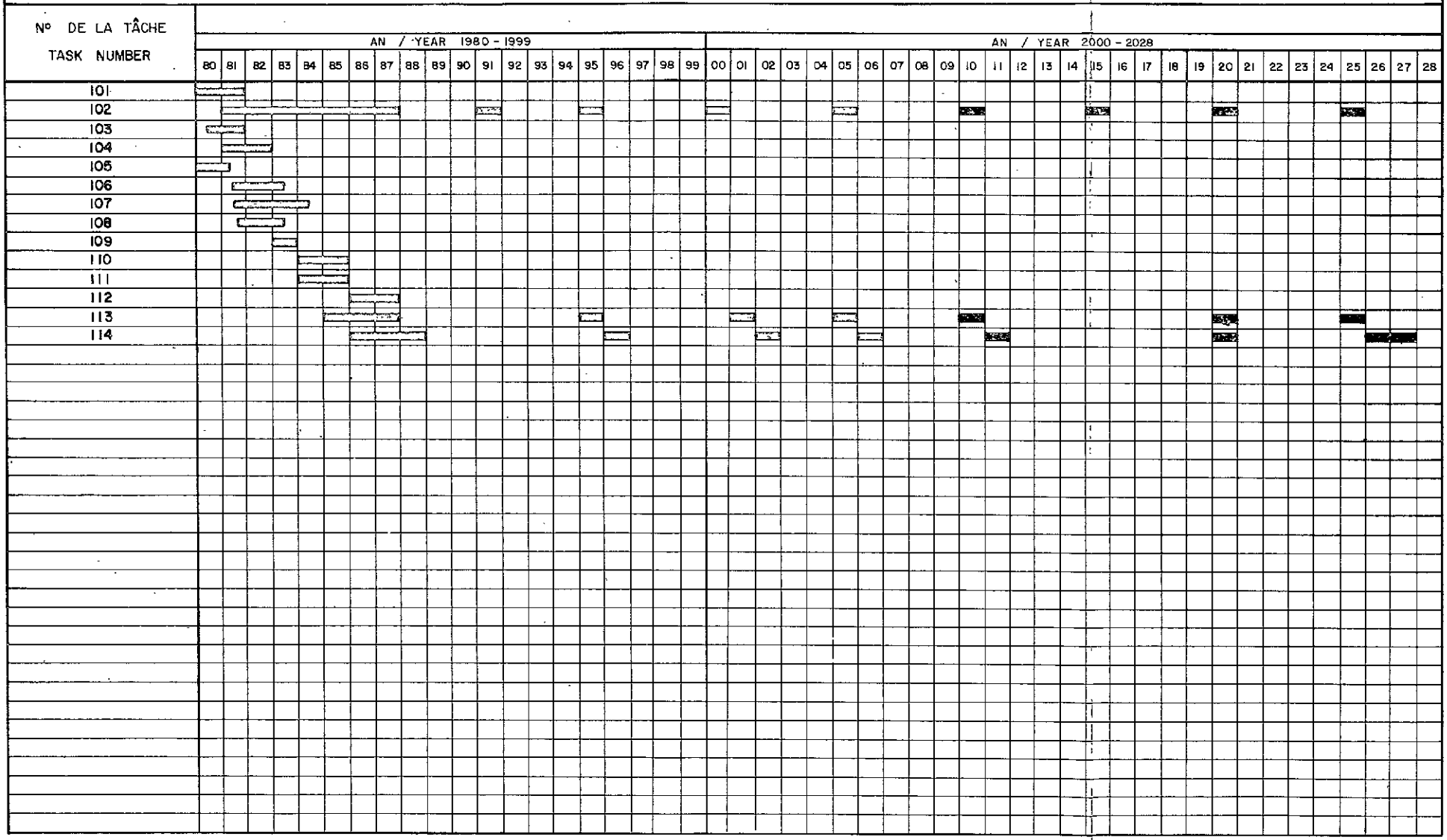


FIGURE II

DIAMA DAM

Adverse impacts from construction of the Diama dam can be mitigated if various actions are incorporated into regional and national plans of the O.M.V.S. and the Member States. Planning of these actions should begin immediately while implementation can take place at various stages of development. Similar actions will also enhance beneficial impacts from operation of the Diama dam. These activities include:

Construction-related recommendations

- Hiring and Salary Practices - A number of policies should be adopted to minimize disruption of agricultural activities and breaking of family ties during dam construction. These include:

  - Wage controls so that construction workers from the agricultural perimeters can hire itinerant labor to take their places on the irrigated perimeters.

  - Giving priority to hiring local residents. This will enable workers to continue working their agricultural plots and minimize disruption of family ties.

  - Liberal agreement to brief leaves of absence from the construction site to facilitate the maintenance of agricultural production and allow continuation of family contacts.

  - Develop, where possible, a quasi-permanent group of semi-skilled construction workers from the urban umemployed leaving more farm workers to work full-time on the irrigated perimeters. This will also reduce the instability caused by the entry and withdrawal of randomly chosen laborers from the work force.

- Transportation to and from Diama Dam Site - Furnish regular transportation to workers traveling to and from the construction zone. Periodic runs by common carrier should be scheduled from the Diama dam site to St.-Louis and to Rosso. This will prevent disruption of family ties and minimize loss of the agricultural labor force allowing individuals to work the irrigated perimeters during off-hours.

- Construction Scheduling - Planning of labor requirements should take place so that dam construction coincides with light agricultural activity permitting maximum use of the labor force by both interests.

- Sediment Control Measures - Specify the sediment control measures to be provided by the contractor and instruct him to include the cost of these in his bid. As the actual measures undertaken will be directly related to the construction procedures followed by the contractor, the specifications for these measures should be performance-oriented with the contractor given an opportunity to improvise as long as performance requirements are being met. The bid documents should include a description of the sediment control measures proposed by the contractor. In the event of noncompliance on the part of the contractor, the inspection engineer should invoke remedies described in the construction contract to assure immediate compliance.

Resettlement-related Recommendations

- Relocations - The 3500 residents from Le Reau, Dieuk and Qualalan in Mauritania, and Ronq, Rhor, Diawar and Thiagar in Senegal must be relocated. Unless relocated, villages presently surrounded by dikes are expected to suffer from seepage, poor drainage during the rainy season and from serious health problems once the Diama impoundment is in operation. No one should be moved farther than necessary from

his present residence. In this manner, his social network will be left intact. His village will not have to absorb any new residents. He will continue to exploit virtually the same resources he has been used to exploiting.

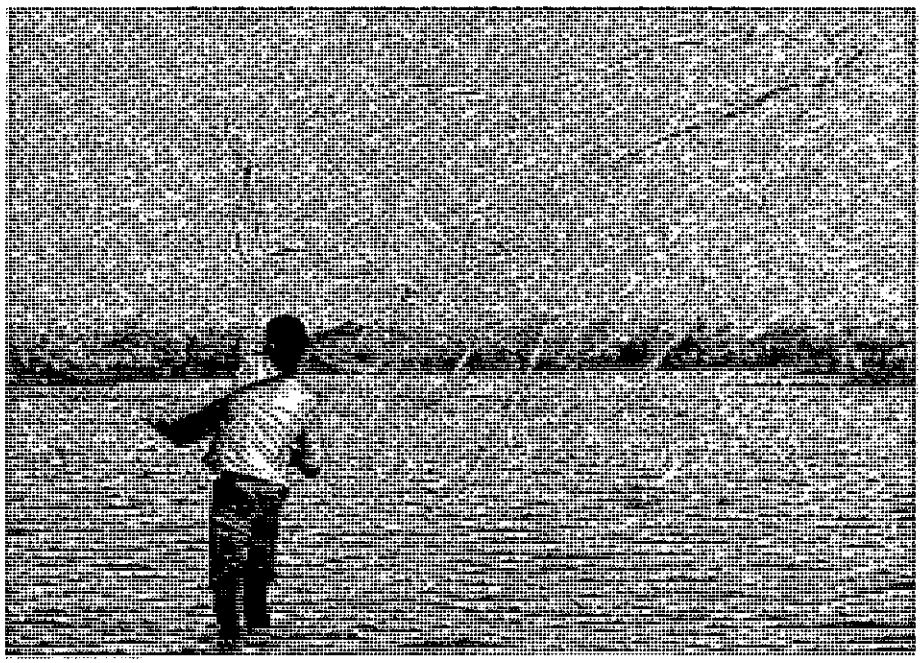
Natural Environment-related Recommendations

- Artificial Estuary - When the Diama dam is constructed, the life cycle of certain important fish species, such as the African Shad, will be interrupted. Creation of an artificial estuary may serve to mitigate this adverse impact if it is functional before the Diama dam is in full use. This Report recommends an immediate feasibility study of the potential for creation of an artificial estuary through the Tianbrank-Diaouling complex. This study will require collection of baseline data to model the quantity of water needed to pass through the canal to provide a natural year-round salinity regime in the estuary, while at the same time assuring permanent freshwater conditions behind the Diama dam. It is also recommended that a year-long, bimonthly biological sampling effort be conducted so that aquatic species whole life cycles are tied to the estuarine environment in the Senegal River Basin can be better understood.

- Fishery Extension Service - Fish are frequently lost by exposure to bacterial and insect infestations associated with improper preservation, storage, and transportation. Because of increased fish demands by the expanded population within the Senegal River Basin, compounded by decreased fish availability as the result of Basin development, there is a need to provide extension services and educational programs for the fishermen, transporters and merchants to minimize the losses of fish from infestation. While such programs are envisioned by Senegal in its Fifth Plan, Basin-wide programs are desirable in this regard. Extension agents can serve as an information link between these subsistence and commercial sectors and national and international institutions who will be developing new technology, and fish management plans.

- Fish Culture - Fish culture, the controlled growth of fish in ponds, should be expanded in the Senegal River Basin. Research stations should be established to develop supplementary fish food from agricultural wastes and to raise fingerlings for stocking fish ponds. Initially, fish ponds should be established on a limited number of agricultural perimeters and be of an easily manageable size (0.5 hectares). The more successful perimeters should be selected for the pilot fish culture programs. Farmers on these perimeters will be more open to such innovative ideas. Past success will help in generating motivation and in promoting future success of fish culture.

- Marine Fisheries - Industrial fishing in the Atlantic Ocean should be increasingly exploited by Senegal and Mauritania and, if necessary, at an accelerated pace. Artisanal fishing should be continually monitored and developed, and provided with the latest transfer of technology. This will require the involvement of an extension service.

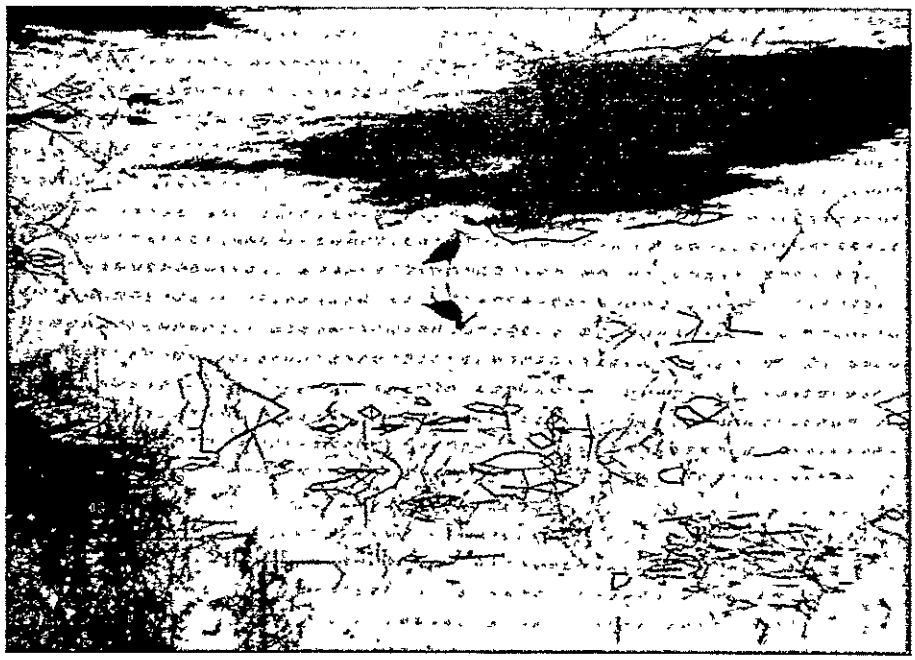


The cast net typically used in the Senegal River Basin to capture fish.

- Riverine Fisheries - Changes to fisheries will occur as a result of Basin development. Major efforts will be required to study and manage the new fisheries, including the collection of baseline information through monitoring and research efforts, application of this information in the form of management plans, dissemination of this information to the fishermen and then enforcement of the guidelines set down by these plans. It cannot be overly stressed that management of the fisheries will not succeed without proper enforcement.

- Harmonization of Fishing Laws - A major goal of O.M.V.S. and the Member States should be to provide improved management of the fishery that will evolve from Basin development.

- Djoudj Dike System - A feasibility study should be conducted on the need for upgrading the existing dike system of the park, including a dike and gate system maintenance program. This study and any dike upgrading should be complete before operation of the Diama dam to assure protection of the park.



Wetlands in the Senegal River Basin.

- Wetland Research - To enhance the beneficial impacts created by development, it is recommended that a wetlands program be established to manage the newly created habitat behind the Diama and Manantali impoundments, and within the natural bodies of water that will receive increased recharge. Incorporated into this program should be continued research on the life cycles and natural histories of the manatee, crocodile, hippopotamus and water birds.

- Wetland Preserves - It is also recommended that additional wetlands be set aside as preserves. It is important that these preserves be set aside now even though funding and plans for development may not exist until sometime into the future. In this manner, habitat will be protected from urban, industrial or agricultural development that may take place in the interim period. The establishment of these preserves should be coordinated to assure that no major land use conflicts exist. This study recommends, as a minimum, that 5000 hectares of habitat be added to Djoudj Park in Senegal and an additional 30,000 hectares be set aside as a wildlife preserve in Mauritania, opposite Djoudj, extending to the Atlantic and including within its perimeters brackish water marshland habitat. As an alternative, the Ndiaels, Mengueye, and portions of the lower Ferlo Valley, should be considered for development as a wetland sanctuary. These wetlands, if artificially recharged on a regular basis, could also serve to increase fish production.

- Harvesting of Gonakie Forests - Forests that would be lost as a result of inundation from the Diama dam and from agricultural development should be harvested by licensed charcoal operators or individual citizens.

- Reforestation Programs - To mitigate the loss of forests from inundation, a reforestation program should be established, especially in association with irrigated perimeters. This complimentary program will allow the use of drainage waters from the perimeters that may

contain levels of pesticides or nutrients which could be harmful if discharged into the aquatic environment. These drainage waters can be used for irrigation of trees. In turn, if strategically located, these trees will act as windbreaks to protect irrigated perimeters from the loss of topsoil, act as a steady source of firewood and charcoal, and provide wildlife habitat. Reforestation should also be practiced on natural stands of gonakie and dieri forest that remain after operation of the dams.

Implementation and Infrastructure Requirements

- Construction Related - The O.M.V.S. should see that these recommendations are incorporated in its contract with firms hired to do construction. The O.M.V.S. should set up a system to monitor adherence to agreements. Monitoring by O.M.V.S. can be done by monthly visits to a construction site by a staff member.

  As manager and operator of all Senegal River infrastructure, O.M.V.S. should establish a process for specifying erosion and sediment controls during construction in its tender and contract management procedures. It should, on that basis, assess penalties to contractors for noncompliance with those construction standards. These activities can be carried out by the existing directorates of O.M.V.S. The Directorate of Regional Infrastructure and the Division of Transport should implement this program.

- Resettlement Related - O.M.V.S. should create a permanent office concerned with all the aspects of the resettlement problem in development of the Senegal River Basin. The first responsibility of this resettlement office will be to organize a study of the overall problem. Such a study will be the prerequisite to action to mitigate the problems of resettlement in the River Valley. The study should take two to three years and should provide its conclusion in time to give the governments of the O.M.V.S. member states an opportunity to

make necessary preparations for population movements. In the case of each type of resettlement, the most important questions to answer are:

- How many people are involved?
- Where will they come from?
- Where will they settle?
- What infrastructural facilities will they need?
- How may good relations with their new neighbors be best established?
- How will they be employed?

On termination of the study, the resettlement office will take on the responsibility of monitoring resettlement in all of its manifestations throughout the Basin.

- Natural Environment Related

  - Artificial Estuary. Because of the need to have the Tianbrank-Diaouling Canal functional before Diama dam is operational, it is recommended that O.M.V.S. immediately obtain funds for a detailed feasibility, design, economic, and environmental assessment of the practicality of constructing an artificial estuary.

  - Fishery Extension Service. The extension service needed to disseminate the latest and most appropriate technology in preservation, transportation, and storage of fish should be developed on a national level within existing governmental institutions of the Member States (Figures 12 & 13). As with other extension activities already proposed for Senegal's fisheries industries in the Fifth Plan, O.M.V.S. should assess needs for extension in the region as well as define some of the

Figure 12

ORGANIZATIONS AND FUNCTIONS INVOLVED IN FISHERIES DEVELOPMENT IN SENEGAL

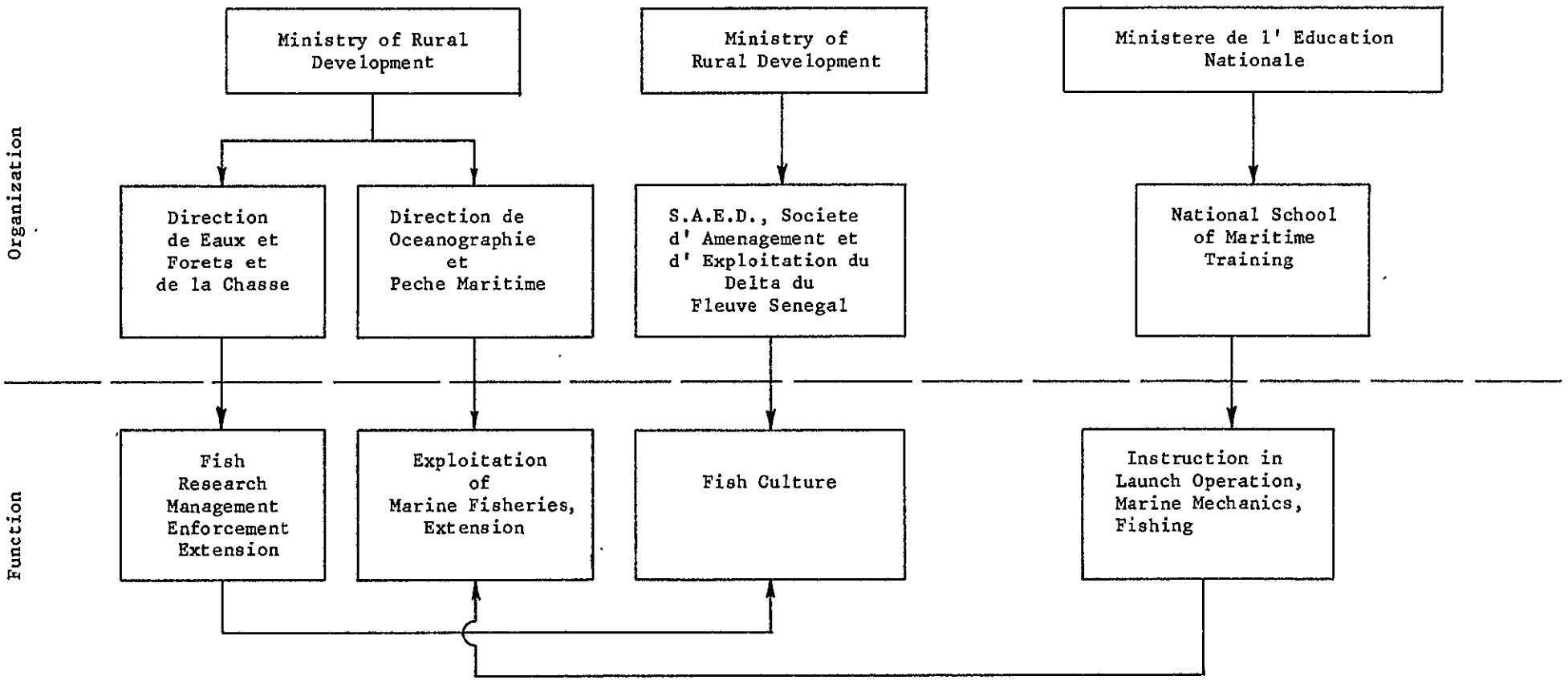
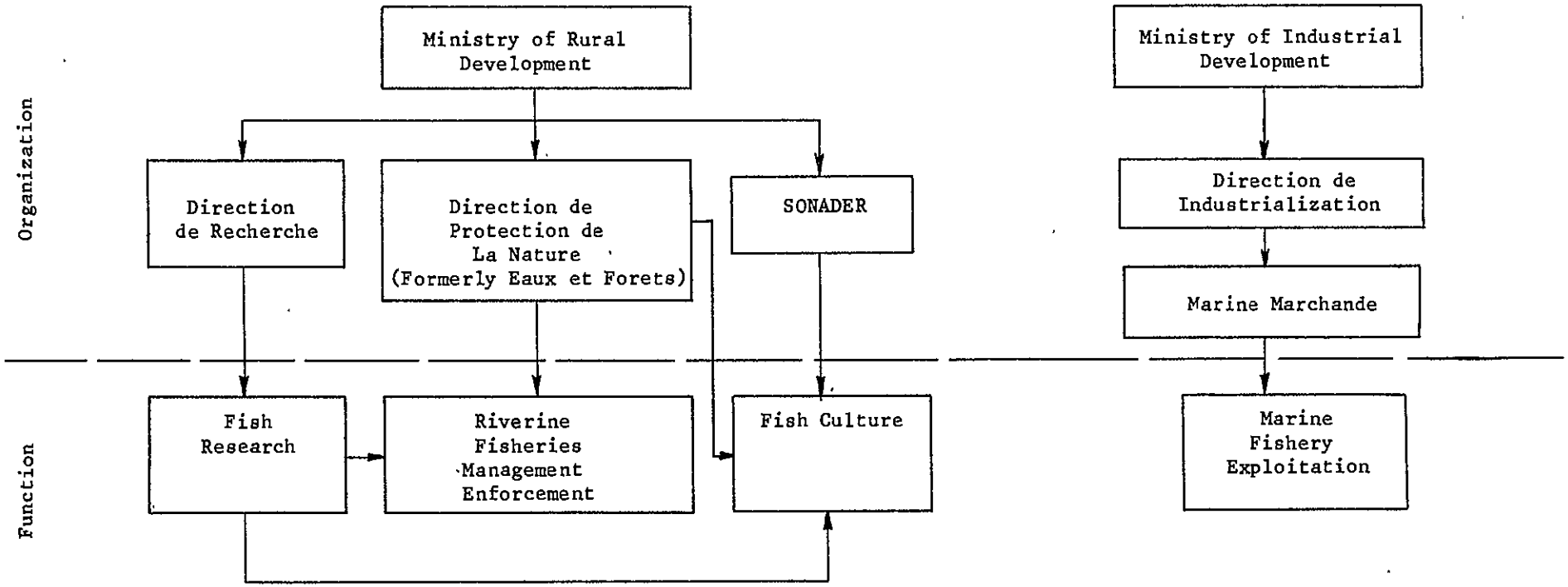


Figure 13

ORGANIZATIONS AND FUNCTIONS INVOLVED IN FISHERIES DEVELOPMENT IN MAURITANIA



major activities to be pursued. It is highly recommended that this service become involved in the fish culture programs associated with the irrigated perimeters. Fisheries extension services will place additional strain on the existing skilled manpower situation. O.M.V.S. can minimize this constraint by establishing an additional exchange program between the three countries, as has been proposed for agricultural extension training. It should also seek on-going training opportunities for the fisheries extension staff to assure they are kept up-to-date on the latest technology. This can be accomplished by scheduling periodic meetings to bring together extension agents from the Member States so that ideas and information can be exchanged and the rates of progress established. O.M.V.S. should develop the broad criteria for improved preservation and storage techniques within extension service programs.

- Fish Culture. Development of fish culture should take place on a national level by the Member States of Senegal, Mali and Mauritania. Significant activity is already being undertaken in Senegal and a body of technical knowledge for fish culture development exists. Disparities exist in the levels of capacity of fish culture between the three Member States. The O.M.V.S. should continue its concern with fish culture by attempting to reduce the technological gap between countries. O.M.V.S. should see its role as one of disseminating and exchanging regional information and experience between Member States as technological advances in fish culture are achieved. As a coordinating agency, O.M.V.S. could convene a regional seminar to establish informal links between governmental agencies of the Member States who will execute and finance the development of fish culture. It should outline the urgency for the development of fish culture in the Basin, particularly emphasizing sources of funding, concepts and available experience in this field.

In a second phase, more detailed technical meetings or short courses in fish culture should be held by O.M.V.S. for the Member States to discuss project scale, land suitability, fish culture techniques and operations at a level that will enable officials to proceed with detailed designs of fish culture programs. Special emphasis should be placed on an evaluation of SAED's fish culture operations (Figure 14). Subsequently, O.M.V.S. should schedule semi-annual or annual follow-up conferences so that progress from research and development in fish culture can be shared and its role in meeting food needs can be placed in perspective with the overall goals and objectives of Basin planning. Information from these meetings should be published and made available as a working document to concerned parties.

Sun drying of marine fish for importation into the Senegal River Basin.

- Marine Fisheries. In a process similar to the development of fish culture, O.M.V.S. should convene an inter-governmental conference on marine fisheries. The major purpose of this conference should be to explain the important links between

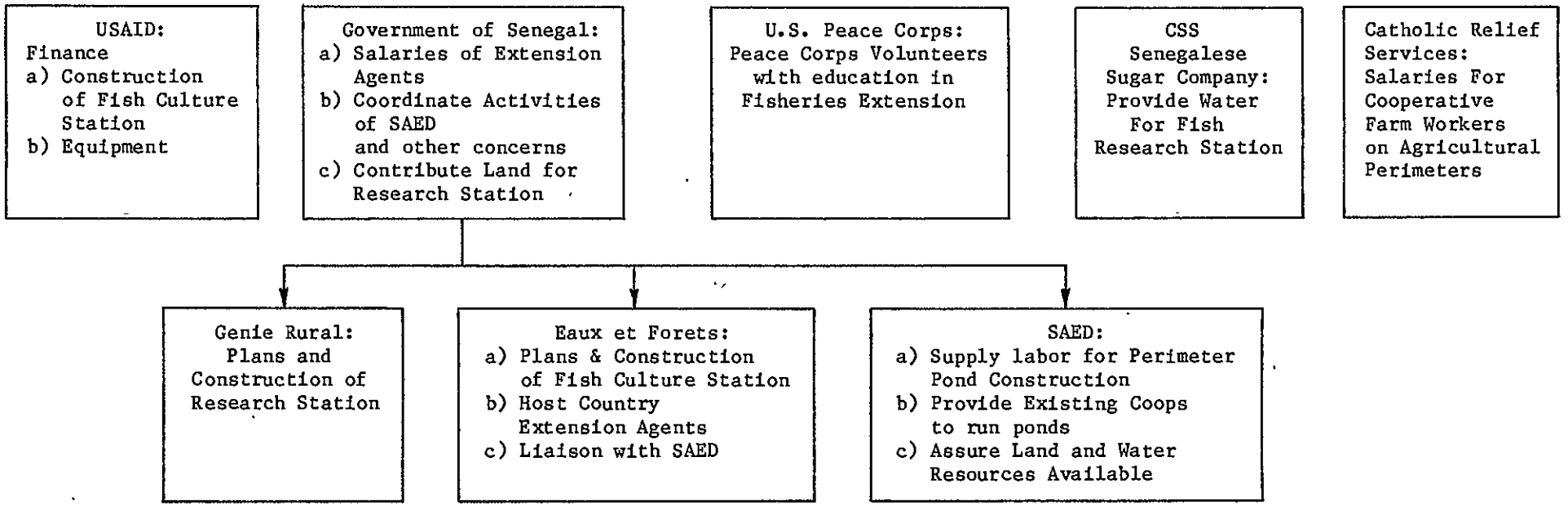
Basin development and marine fisheries. Increased exploitation of the marine fisheries is now proceeding in both Senegal and Mauritania. The O.M.V.S., in attempting to solve a regional problem, can assist the national agencies in determining the market demand for fish on a national scale and the subsequent rate of marine fisheries development. The Directorate of Oceanography and Marine Fisheries in Senegal and the Directorate of Industrialization in Mauritania, as well as other planning and implementing agencies, will have to devise strategies to see that more ocean fish are allocated to this region. This may include legislation regulating the ratio of marine fish for export versus local consumption, developing marketing infrastructure and regulating exploitation of the maritime fishery by foreign concessionaires.

- Riverine Fisheries. Development will not only impact regional demand and availability of fish but will also affect the livelihood of a portion of the 10,000 commercial and 10,000 subsistence-level fishermen residing in the Senegal River Basin. These adverse impacts can be partially offset by the establishment of a riverine fishery management program that should include harmonization of fish conservation regulations, modernization of fishing equipment and technology, and continual research activities.

Ministerial-level contacts calling for harmonization of fisheries laws among the three countries have been recently initiated by Senegal's Ministry of Rural Development and should be supported by O.M.V.S. Coordination by O.M.V.S. will become important in the development of common laws between Member States, such as limiting use of equipment and regulating the size and species of fish to be harvested. Establishment of multi-national laws will be critical in the early years of Basin development when major changes will occur in the population

Figure 14

EXISTING FISH CULTURE PLANS FOR SENEGAL



dynamics of the aquatic ecosystem, primarily from the effects of dam implacement and flow regulation. Conservation measures must be established to protect the fishery until natural predator/prey relationships produce balanced populations of harvestable fish. The implementation of these statutes can be successful only if proper enforcement can be assured by all Member States. The expansion of fish cooperatives and the creation of an extension service to disseminate information and educate fishermen are final pre-requisites for development of the riverine fishery.

- Wetland Management and Research. The wetlands management program to mitigate the damage to wildlife habitat should begin immediately. The Government of Senegal, with technical assistance from O.M.V.S., should conduct feasibility studies on the need for upgrading the existing dike system of Djoudj park. The Government of Senegal should also insure that dike and gate maintenance is effectively carried out. To protect the expanded wetland preserves recommended by this Report, the Member States should increase the number of park conservation officers. Specific research on the life cycles of various wildlife should be conducted by the O.M.V.S. using appropriate national and expatriate staff.

- Harvesting of Gonakie Forests. Forests to be inundated by the Diama impoundment should be harvested under the supervision of the O.M.V.S divisions in charge of construction, along with the following Senegalese organizations:

  - National Center of Forestry Research

  - Ministry of Rural Development, Directorate of Water, Forests and Wildlife.

Mauritania should simultaneously provide similar supervision under the following agencies:

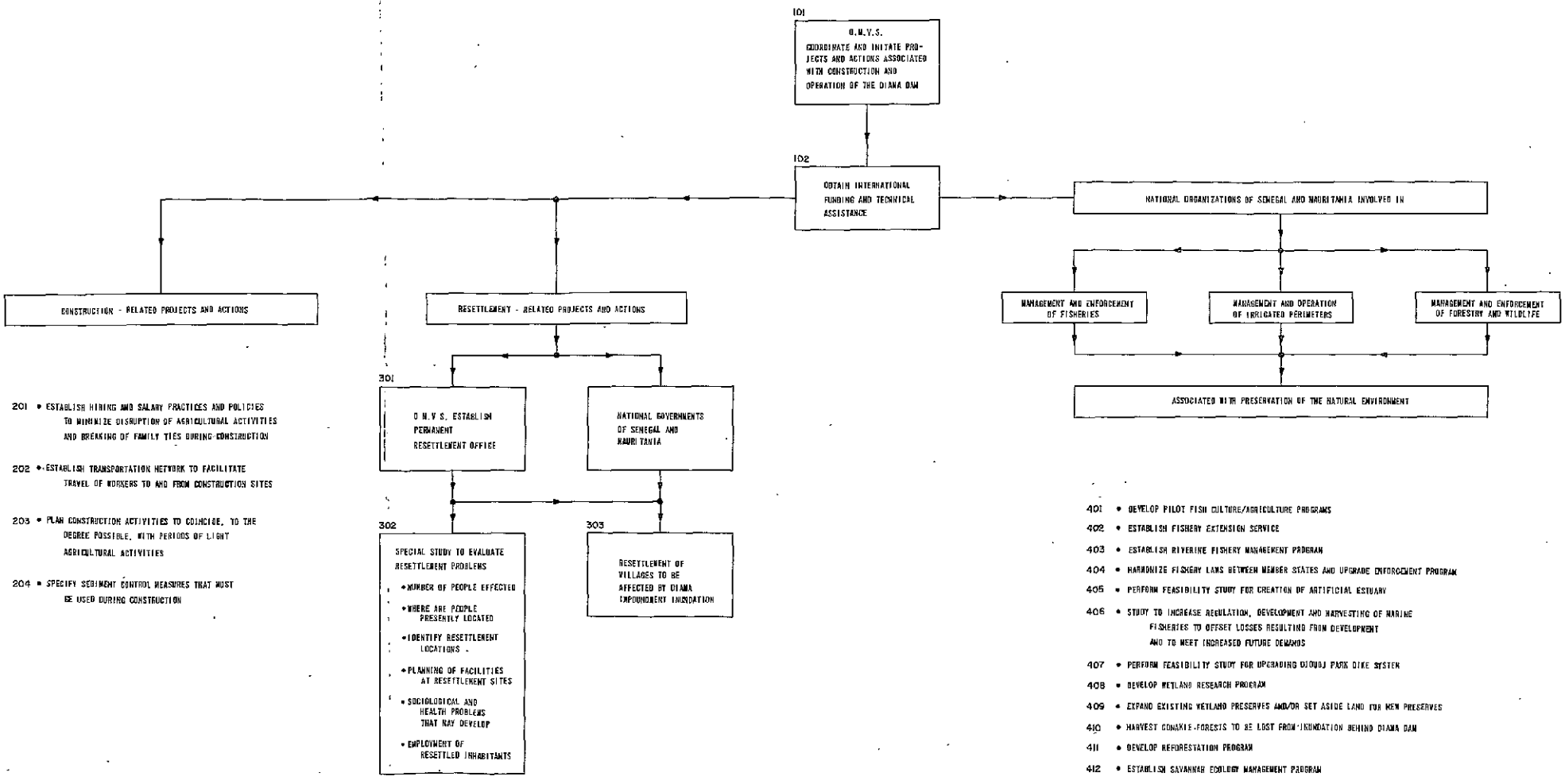
- Ministry of Rural Development, Directorate for Protection of Nature.

- Directorate of Water, Forests, and Wildlife.

- Reforestation Programs. Within the context of master planning through O.M.V.S., implementation should be carried out by the national agencies listed above as well as the agricultural development organizations of SAED and SONADER. Special attention should be given to placing foresters within the irrigated perimeter organizations where they do not exist at present.

  Attention should also be given to establishing links between reforestation, forage growth within perimeters, livestock, and plans developed to manage open-range grazing in the Basin. O.M.V.S. should inventory such possibilities as part of its land and water use planning activities.

  Reforestation projects must also include improvement of forest management practices at the local level to assure planned yields and preservation of natural habitat. Existing training programs for forestry personnel should include extension methods to educate local populations. Special outreach programs proposed by various international agencies should be consulted for an organizational format capable of reaching both sedentary and nomadic populations within a region.



DIAMA DAM
PLAN OF ACTION

FIGURE 15

PROGRAMMATION DES ACTIVITES CONCERNANT LE BARRAGE DE DIAMA

PROGRAM SCHEDULING ASSOCIATED WITH THE DIAMA DAM

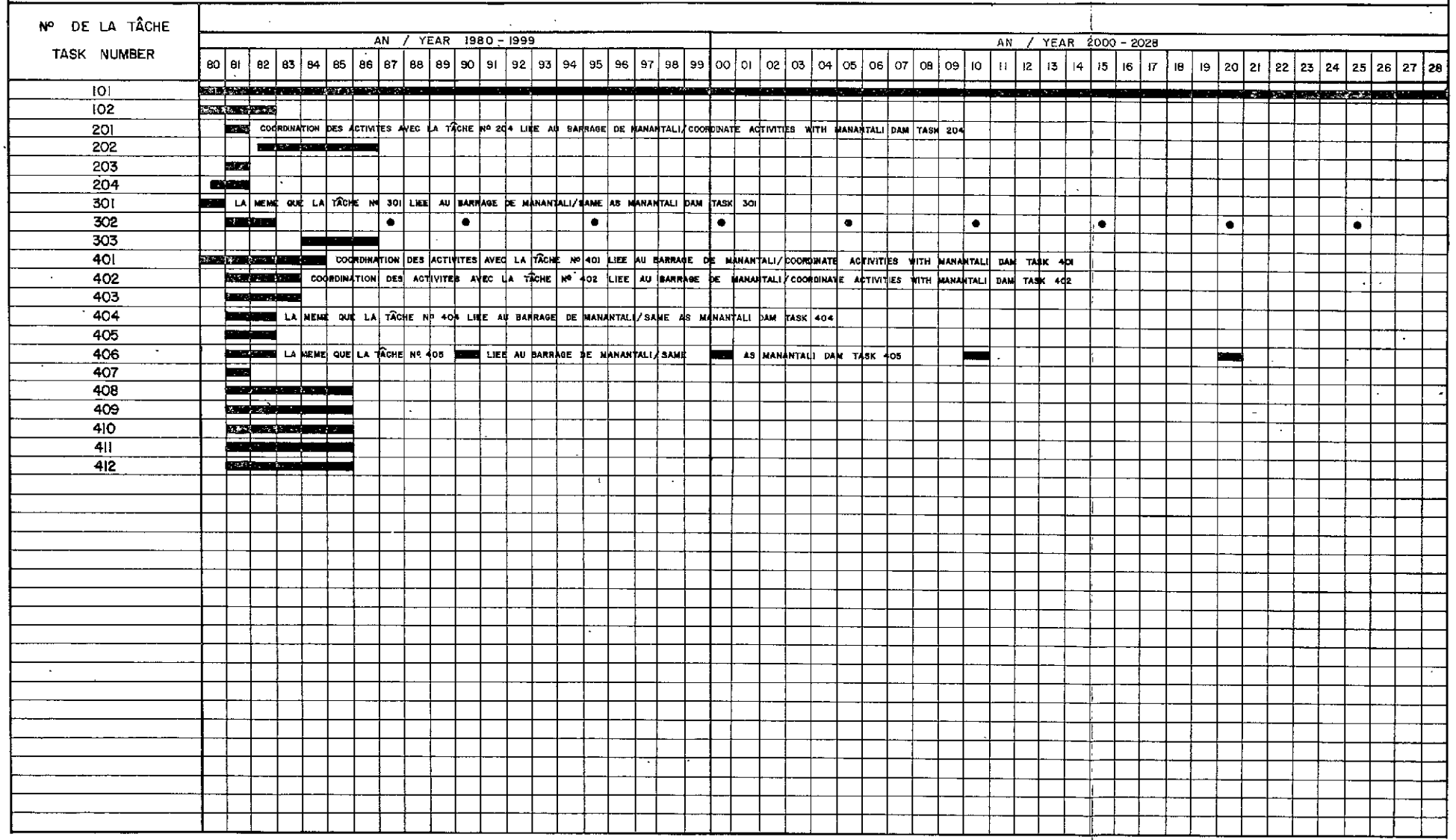


FIGURE 16

MANANTALI DAM

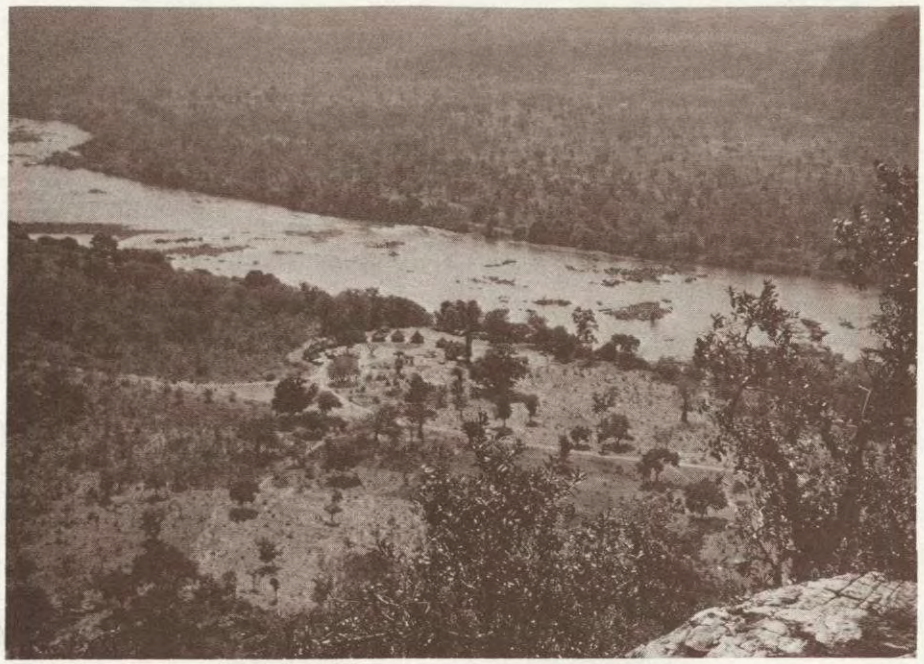
The proposed plan of action includes measures to mitigate impacts in the Manantali area resulting from constructing the dam and creating the impoundment. These proposed actions are associated with construction and resettlement activities and natural resources. Many of the actions associated with the Diama dam are also applicable to the Manantali dam and are not reported here.

Construction-related Recommendations

- Housing and Related Infrastructure - Because the Manantali dam site is isolated from urban centers to the extent that prohibits daily transportation of workers, there is no alternative but to provide on-site housing for the workers.

  The least expensive alternative would be to advance construction of the resettlement villages to the point that they would be habitable by the dam construction workers. Another advantage would be a head start in completion of the relocated villages. It would mean that the villagers would be guaranteed certain essential elements of infrastructure such as wells, roads, sanitation facilities and village centers before they had to relocate.

  The contractor will have to permit the establishment of a limited number of shops in the construction camp. Mosque construction will be necessary. A post office will be an essential infrastructural development. Most workers will send remittances to their families in the form of postal money orders.



Village to be inundated by the Manantali impoundment.

- Physical Examinations for Workers - Unlike the Diama dam site and because of its isolation from populated areas, workers are expected to be drawn from a wide area, many from outside the Basin. Additionally, workers will be in closer contact than at Diama; not only working together but living together. It is therefore recommended that medical examinations be conducted on all workers prior to employment to reduce the transmission of communicable diseases and to minimize the potential outbreak of epidemic conditions and lost time due to illness at the construction site.

- Sediment Control Measures - As with the Diama dam, erosion controls should be specified to impede sediment pollution of the Senegal River.

Resettlement-related Recommendations

- Maintain Social Stability - Village chiefs, religious figures and hunters, who are traditional village leaders should be given a voice in selecting sites of resettled villages and allocation of land.

Because resettlement communities will require consolidation of several formerly independent villages, managing tensions generated within will be difficult. The tensions can be mitigated by giving each constituent village reasonable autonomy. In a given consolidated village there will therefore be several chiefs and land chiefs. Each constituent village will manage its lands independently. Such internal autonomy may conflict with the requirements of efficient administration. In such a case, the more the administration can concede to local autonomy, the more it can mitigate internal tensions.

- Minimizing Social Conflicts Between Existing and Resettled Inhabitants - Tensions between the population already inhabiting the resettlement zone and the new populations can be mitigated by a balanced treatment of both populations. The quality of life in the old villages should be raised to that of the new village including construction of improved wells, schools, and provision of materials for inhabitants to construct or improve their dwellings in the older villages.

Natural Environment-related Recommendations

- Monitoring and Management of the New Manantali Fishery - As is typical of new reservoirs, the early years of the Manantali reservoir will see widely fluctuating fish populations. These populations and the commercial fishery expected to develop must be closely monitored to assure the eventual success of a stable fishery that provides a maximum sustained yield. This should include regulating fishery gear, monitoring fishermen's catches and performing baseline aquatic biological surveys. If it is found that either fish populations are not developing at the desirable rate or various niches in the fishery food chain are not being filled, a stocking program may be foreseeable using fish indigenous to the Senegal River Basin that can best survive in a lake environment.

- Fishery Extension Service - As with the Diama dam, a fisheries extension program should be instituted to assure use of the most efficient gear for fish harvesting, and to assure proper handling, preservation, storage and transportation of fish catches.

- Wildlife Preserve - A 40,000 hectare national park in Mali should be developed to surround and incorporate 45 kilometers of shoreline along the Manantali impoundment. This park will include both fringe and savannah land forests. As an alternative, 40,000 hectares could be added to Parc National de la Boucle de Baoule near Bamako.

- Savannah Ecology Program - In association with the above recommended national park and other preserves within the Basin, a savannah ecology research and management program should be established with close ties to the management of livestock and forests.

- Harvesting of Forests - It is recommended that harvesting take place on the 47,000 hectares of forest savannah land and 681 hectares of fringe forests to be inundated behind the Manantali dam. On the assumption that 85 percent of these forests are accessible, approximately 36,000 hectares of dryland forest are salvageable.

- Reforestation - Associated with the establishment of the wildlife preserve and resettlement villages, reforestation should be practiced to provide improved wildlife habitat and to assure a steady source of firewood and charcoal.

Implementation and Infrastructure Requirements

- Construction Related - The O.M.V.S. should fill the same functions as recommended for the Diama dam.

- Resettlement Related - The resettlement of villages in the Manantali impoundment has been planned as an integral part of the O.M.V.S.

development program for the construction of the Manantali dam (Groupement Manantali, 1977). The loss of homes in the impoundment area is an irreversible impact. Replacement of lost homes must be carefully planned with the full participation of the individuals concerned. Preparations must begin early so that the infrastructure is in place and functioning when resettlement begins. With early preparation the new areas could serve workers engaged in the construction of the Manantali dam.

- Natural Environment-related

  - Fisheries. Implementation would be similar to that recommended for the Diama dam. national organizations to be involved in the development of the Manantali fishery are presented in Figure 17.

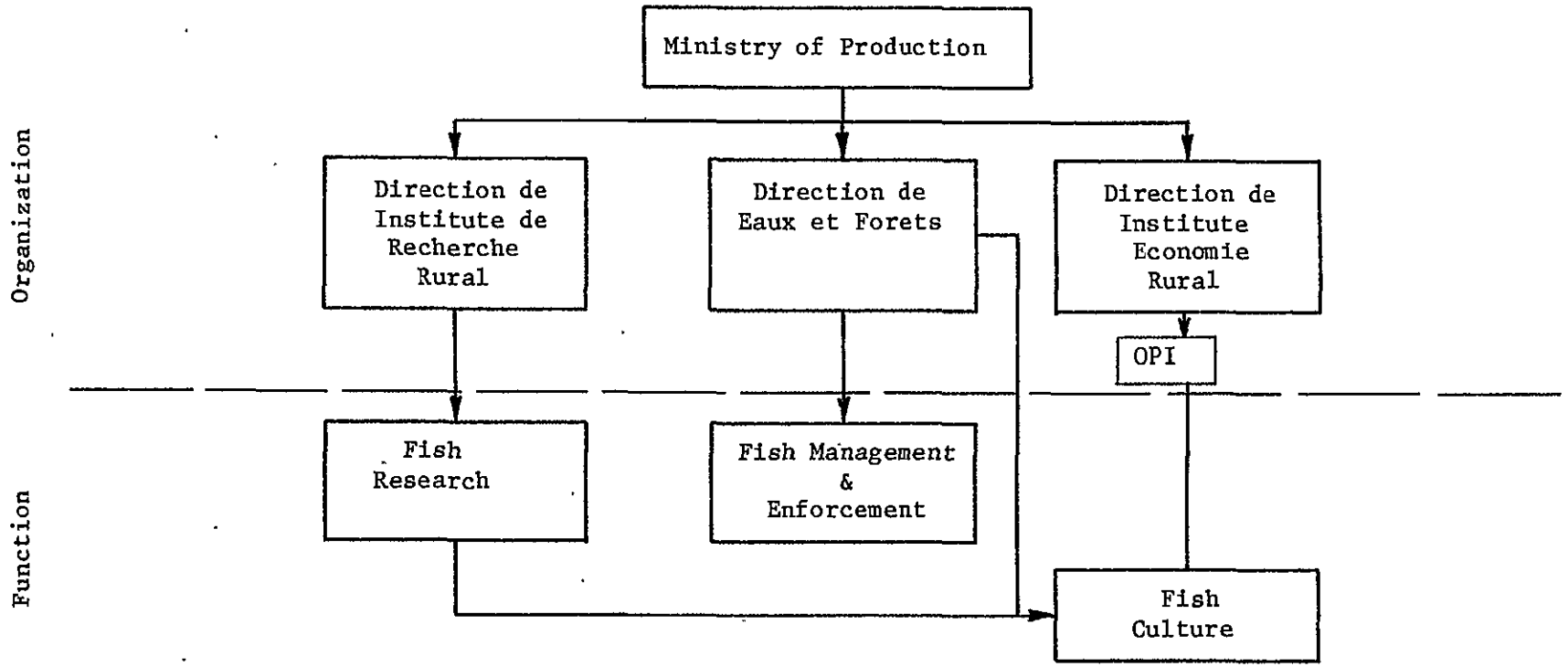
  - Wildlife Preserve. The creation of a 40,000 hectare national park in Mali should also conform to land and water planning recommendations. This proposed park constitutes a portion of the impoundment's watershed and may serve as habitat for the wildlife displaced by the Manantali impoundment. Additional park Conservation Officers are needed to patrol and protect the use of this preserve. Planning for this park and watershed area should be closely coordinated by O.M.V.S. with the resettlement of residents from the impoundment area. Organizations to be involved in addition to O.M.V.S. include:

    - Directorate, Institute of Rural Economy, Mali;
    - Directorate of Planning Social Affairs Commission and the Commission on the Rural Economy, Mali;
    - Directorate of Water, Forests, and Wildlife.

  - Savannah Ecology. Savannah lands management cannot continue to be separated from overall land management, including forest and water use management. At present, range management and live-

Figure 17

ORGANIZATIONS AND FUNCTIONS INVOLVED IN
FISHERIES DEVELOPMENT IN MALI



stock regulation are functionally separated from other national agencies concerned with resource management. This condition exists, despite the painful lessons of the last drought showing the close linkages between overgrazing, deforestation, and desertification. In addition, it is recommended that existing regional data on Savannah ecology be assembled. The synthesis of available information can lead to the development of specific projects. Organizations to be involved in this process should also include;

From Senegal:

- Senegalese Agronomic Research Institute
- SODESP - National Society for the Raising of Livestock in the Pastoral Zone
- Center for Livestock Improvement
- SONAFOR - National Drilling Society
- Directorate of Water, Forests, and Wildlife

From Mauritania:

- Ministry of Rural Development, Livestock Directorate
- ENFVA: National School for Training and Agricultural Extension, Kaedi
- Directorate of Water, Forests, and Wildlife

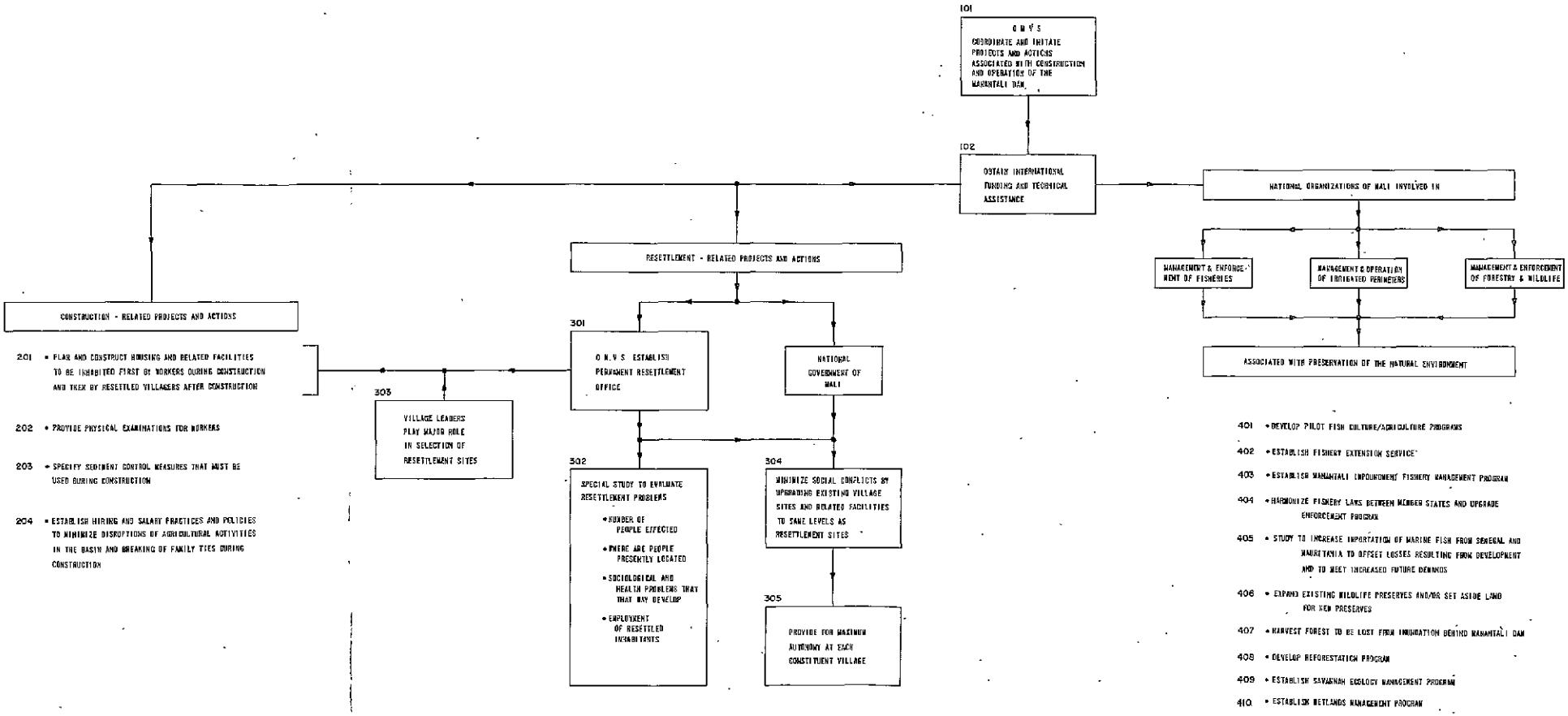
From Mali:

- Ministry of Production, Livestock Directorate
- Rural Polytechnic Institute, Katibougou
- Directorate of Water, Forests, and Wildlife
- Institute for Rural Research-Forestry

- Harvesting of Forests - Forests to be inundated behind the Manantali dam should be harvested of under the supervision of the O.M.V.S. divisions in charge of construction and the Malian Ministry of

Production, Directorate for Water, Forests, and Wildlife and the Malian Institute for Rural Research-Forestry. Assuming 100 workers are provided a minimum of 2 years will be needed to clear the 36,000 hectares, assuming complete felling, loading and hauling, at a rate of 0.5 hectares per worker per day.

- Reforestation - The reforestation program should be coordinated by O.M.V.S. among the three Member States. In Mali, the Ministry of Production, Directorate for Water, Forests and Wildlife and the Institute for Rural Research-Forestry should be involved in the reforestation program. Additionally, any reforestation program associated with irrigation agriculture should be coordinated with OPI, the Malian government organization responsible for the irrigated perimeters.



MANANTALI DAM
PLAN OF ACTION

FIGURE 18

PROGRAMMATION DES ACTIVITES CONCERNANT LE BARRAGE DE MANANTALI

PROGRAM SCHEDULING ASSOCIATED WITH THE MANANTALI DAM

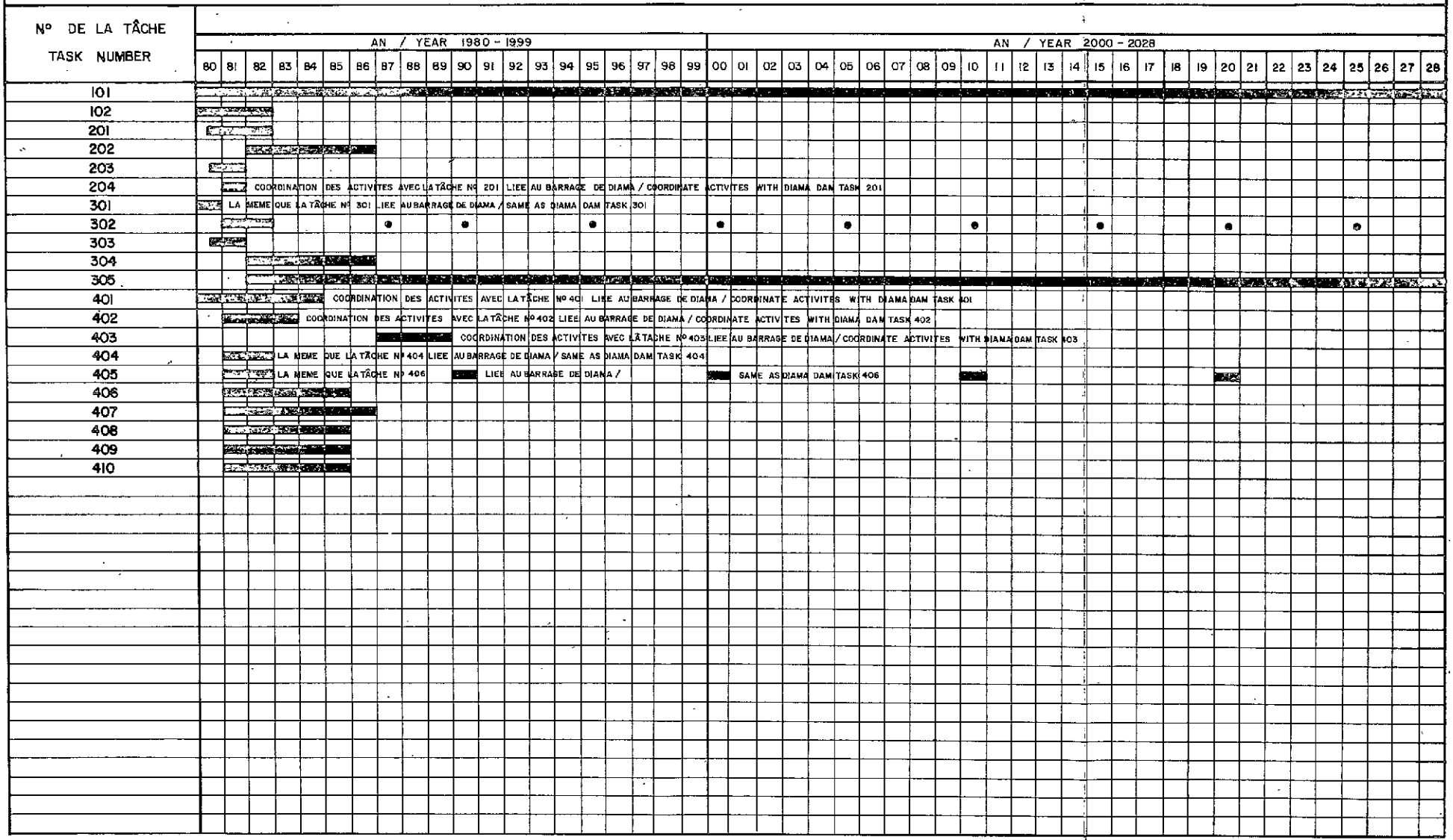


FIGURE 19

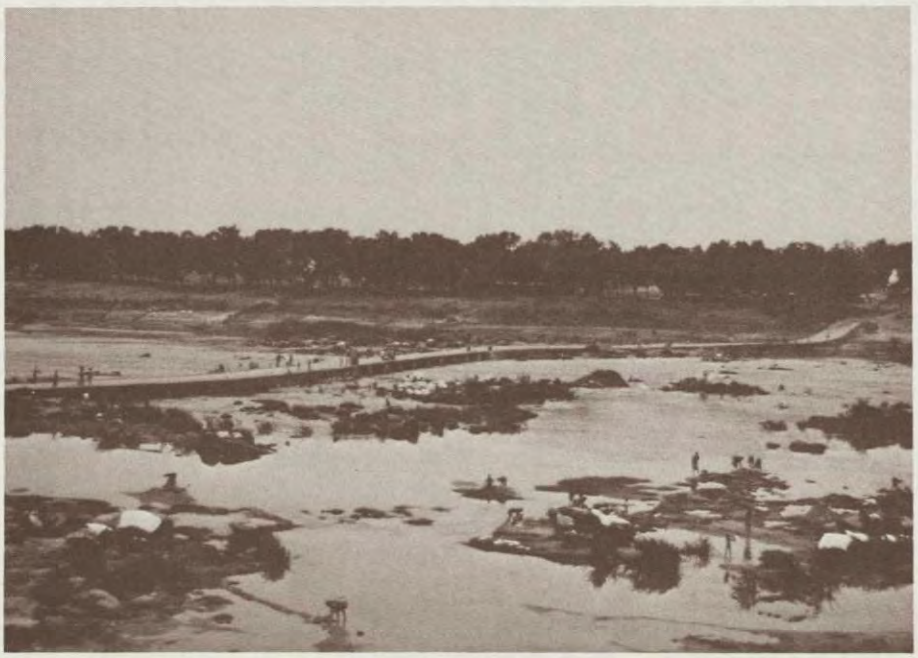
NAVIGATION

Improved navigation of the Senegal River Basin will enhance agricultural development and promote establishment of industries. Construction of a navigation channel through the Langue de Barbarie may have serious adverse ecological implications on this unique habitat. Routine and accidental discharges of pollutants; particularly oil, may deteriorate water quality in the River. The following actions will assure that navigation provides maximum benefits to Basin development.

First of all, the O.M.V.S should establish two organizations:

- La Direction de la Voie Navigable would be responsible for maintenance of the river channel, navigational safety and enforcement of the navigational code.

- Le Compagnie Inter-Etats de la Navigation would be a parastatal organization directly responsible for the acquisition and operation of a river transport fleet and establishment of a joint navigational school.



Low water levels presently prevent commercial river traffic. Note: Picture shows the only bridge on the River upstream of St.-Louis.

The organizations should be formed far enough in advance to support development of the navigation code, and navigational school. Following the foundation of both the Direction de la Voie Navigable and the Compagnie Inter-Etats de la Navigation, both organizations must be staffed by the following key personnel:

- Head of the Division of Navigation Administration in the Direction de la Voie Navigable;
- Head of the Division of Technical Administration in the Direction de la Voie Navigable;
- Head of the Division of Operations - Navigation in the Compagnie Inter-Etats de la Navigation:

The initial assignment for these individuals would be to set up the organizational structure to enforce the basic codes prescribed in this Report, and to consult appropriate agencies on the preparation of those codes.

Development of a Navigation Code

A navigation code for the Senegal River Basin should be developed according to the Intergovernmental Maritime Consultative Organization regulations for transportation of hazardous materials, the 1972 UNDP/OERS navigation code developed by N. H. Naguib for the Senegal River and the Groupement Lackner, Dorsch and Electrowatt (1978) Navigation Study. The outcome of this code should be:

- The promulgation and enforcement of comprehensive pollution regulations for riverine and estuarine areas regulating discharge of pollutants from shipping;

- Promulgation and enforcement of navigation safety regulations including ship construction, equipment standards, navigational systems and regulations;

- Enactment and enforcement of port transfer and storage regulations covering equipment and procedures for the handling of hazardous materials, primarily oil, but also toxic substances;

- Preparation and operation of emergency abatement measures to contain and cleanup spillage based on prepared contingency plans.

Enactment of the Navigation Code

Immediately upon the formation of guidelines, experts should be selected to aid in the development of a comprehensive code for navigation on the Senegal River. The draft code would then be presented to the Direction de la Voie Navigable for review. The Direction de la Voie Navigable should initiate meetings and involve the following agencies in the review of the proposed code:

- O.M.V.S.:
  - Direction de la Voie Navigable;
  - Compagnie Inter-Etats de la Navigation;
  - Permanent Committee on Water-Use;
  - Council of Ministers;
  - Committee on the Environment;
  - Direction for Regional Infrastructure - Transport Division.

- Member States:
  - Member State Coordinators to O.M.V.S.

- Senegal:
  - Ministry of Industrial Development and Environment, Bureau of Environment Coordination;
  - Ministry of Public Works, Cities and Transport.

- Mali:
  - Mali Navigation Commission;
  - Ministry of Industrial Development Direction for Hydrology and Energy;
  - Ministry of Transport.

- Mauritania:
  - Ministry of Public Works, Direction of Public Works, Division of Ports and Navigation;
  - Ministry of Industrial Development.

- International Agencies:
  - United Nations Maritime Agency;
  - European Economic Community.

Enforcement of the Navigation Code

Enactment of laws harmonizing or integrating a navigation code, including enforcement powers, poses some issues of legal jurisdiction between the Member States and O.M.V.S. According to some legal interpretations, regulations passed by the O.M.V.S. Conference of Heads of State and Council of Ministers supercede conflicting national laws at the time of enactment. Member States then have the responsibility to revise their corporate laws. Disruption of existing legal and organizational regimes can be minimized by defining the areas of O.M.V.S. jurisdiction very carefully.

- Pollution Control Regulations - Within the Direction de la Voie Navigable, Port Officer positions should be established as a major regulatory arm of O.M.V.S. Among their major functions will be the enforcement of codes related to pollution control and navigation safety. They can be trained by the navigation school with the assistance of the United Nations Maritime Agency.

- Ship Construction Standards - Licensing of ships falls under the responsibility of the Division of Navigation Administration within the Direction de la Voie Navigable. They would insure that standards designated for safe transport were complied with in the construction of barges and tugs by the Compagnie Inter-Etats de la Navigation or other firms. Periodic inspection could also be a function of the Navigation Sub-Division, specifically the Port Officers recommended above.

- Port Transfer and Storage Standards - Within O.M.V.S., the Directorate of Regional Infrastructure, particularly the Transport Division, can standardize the specifications for transfer and storage equipment as proposed in this Report. At the time of issuing contract tenders for port facility construction, the Division of Work Administration (Administration des Ouvrages Communs) of the Directorate of Regional Infrastructure should specify these standards.

  Within the Compagnie Inter-Etats de la Navigation, similar procedures can be followed if that organization assumes responsibility for construction and operation of port transfer and storage facilities. Technical specifications must be coordinated between the O.M.V.S.

Directorate for Regional Infrastructure and the Compagnie to ensure compatability of equipment and procedures.

The Division of Navigation Administration, Direction de la Voie Navigable will be responsible for harmonizing licensing and inspecting port facilities standards.

- Navigational Safety Measures - The existing Lighthouse and Beacon Service (Service de Phares et Balises) should coordinate maintenance and operation of the estuary channel.

  The Division of Navigation Administration of the Direction de la Voie Navigable will be responsible for the coordination, maintenance and operation of the river channel.

  The Technical Division, Maintenance Sub-Division of the Direction de la Voie Navigable will carry out actual channel maintenance including the repair of beacons, dredging, construction of channel facilities, salvage and continuing channel monitoring.

- Emergency Abatement Measures - One of the tasks of the Director of the Direction de la Voie Navigable should be to establish emergency contingency plans to facilitate notification of agencies, and provide for containment and disposal of hazardous substances in the event of a serious discharge. These measures and the authority to carry them out would be the responsibility of the Director's technical division. Designation of

equipment would also be the responsibility of the technical division, while maintenance of emergency equipment would be the responsibility of port officers.

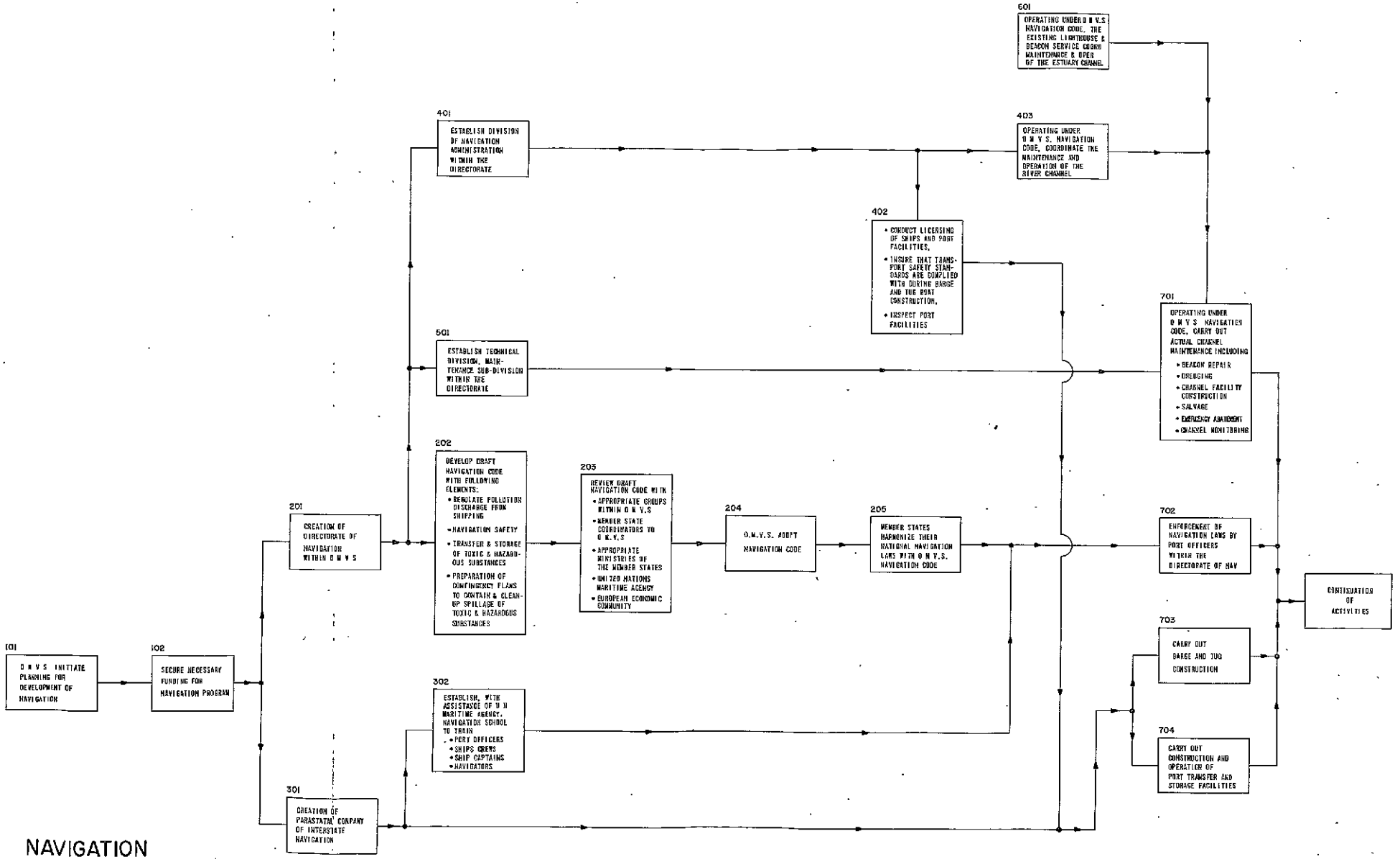
Other Navigation-related Recommendations

- Dredge Spoils - Dredge spoil disposal studies should be added to the terms of reference of the proposed St.-Louis harbor study being funded by the Canadian International Development Agency. The results of the Canadian study can be used to regulate dredging operations and to identify suitable dredge spoil disposal sites.

- Sediment Control - Measures should be enacted to control sediment pollution and bank erosion in the improvement of the navigation channel.

- Ecology of the Langue de Barbarie - The proposed estuary and harbor study should be executed to select optimum channel design minimally impacting the delicate ecological balance of the Langue de Barbarie.

- Enhancement of Employment from Navigation - The essentially positive impact of the navigation program can be enhanced by keeping operations at a labor intensive level and by keeping thé salaries at competitive levels. Labor intensive operations create more jobs, especially unskilled jobs, than do capital intensive operations.



NAVIGATION PLAN OF ACTION

FIGURE 20

PROGRAMMATION DES ACTIVITES CONCERNANT LA NAVIGATION DANS LE BASSIN DU FLEUVE SENEGAL

PROGRAM SCHEDULING ASSOCIATED WITH NAVIGATION IN THE SENEGAL RIVER BASIN

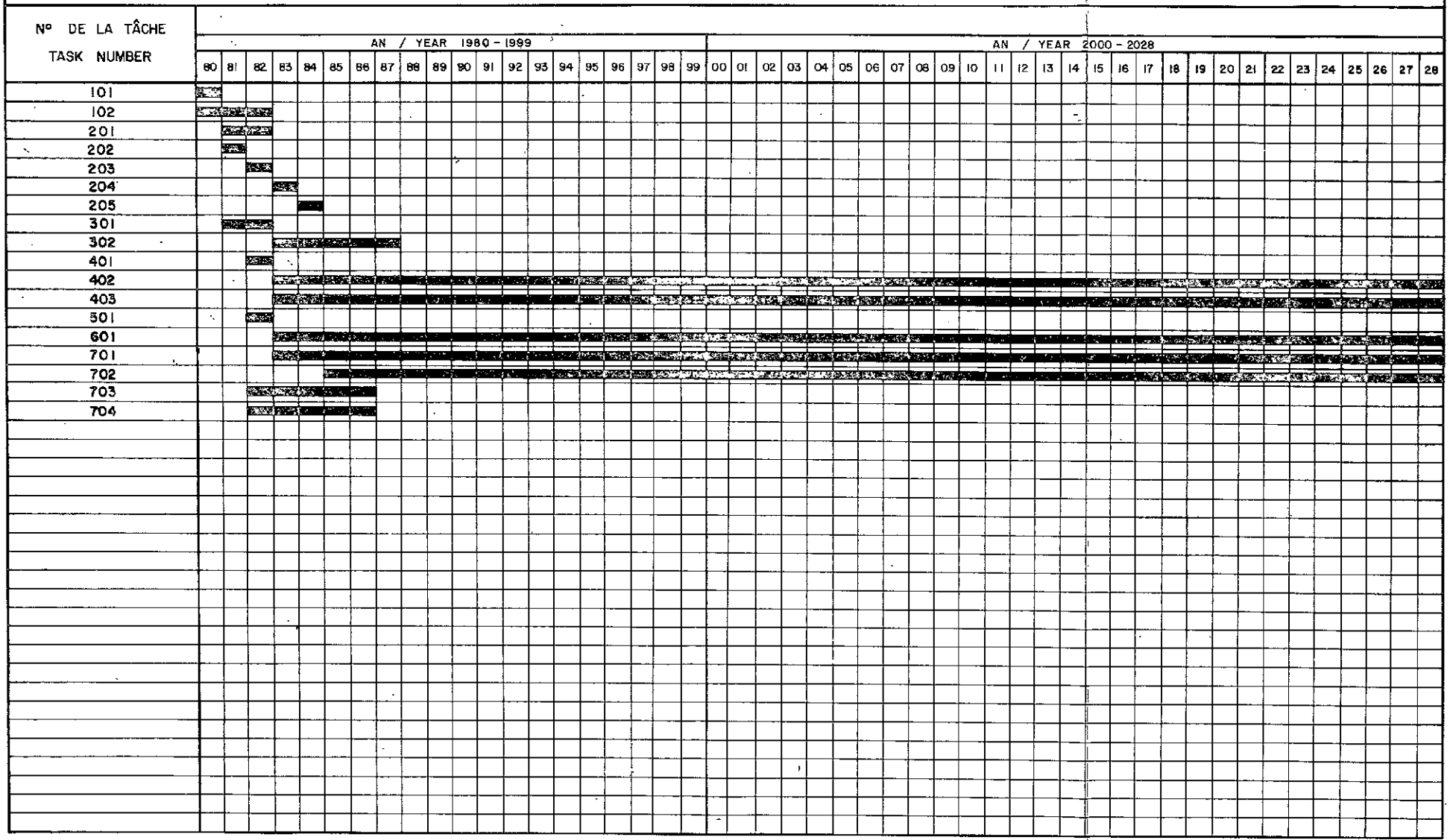


FIGURE 21

AGRICULTURAL DEVELOPMENT

The analyses of the existing regional agricultural and livestock programs indicate the need for a number of corrective measures that must be taken to reduce potential adverse environmental impacts and maximize socioeconomic benefits. The large-scale, regional transformation and development of agriculture planned by the O.M.V.S. Member States requires literally hundreds of supporting activities to be carried out. The implementing agencies covering preparation and operation of the irrigated perimeters, SAED, SONADER and OPI, ministries concerned with livestock, and the various research organizations of Senegal, Mauritania and Mali are attempting to reorganize their task relationships and train the manpower needed for these activities. Nevertheless, the problems identified can become extremely serious in the coming years and the need for concerted action cannot be overemphasized.

Irrigated Perimeter-related Recommendations

- Rates of Development for Irrigated Perimeters and Employment - This Report and others have specified that the rate of planned development of irrigated perimeters is unrealistic, given the problems of actually setting up the physical facilities and managing them. The planned rates of irrigation development were intended to absorb farmers displaced from recessional farming when the controlled flooding is stopped in 2002. The irrigated perimeters were intended to both increase productivity and minimize the net unemployment due to the transition from recession farming. With the suggested modifications in the rate of perimeter development, a number of issues concerning production and employment levels must be examined by the O.M.V.S. High Commission. A number of policy options and plans are possible:

    - Most obvious is a decision to minimize agricultural unemployment by mounting a concentrated and accelerated effort to develop the perimeters and then to proceed with the planned schedule for ceasing artificial flooding by 2002.

- If the above option cannot be followed, production and employment can be maximized by extending the period for artificial flooding until the irrigated perimeters are capable of providing acceptable production levels and employment for a significant percentage of the farmers to be displaced from recession agriculture.

- Additionally, water resource and agricultural planning might proceed at a rate determined by overall employment possibilities generated by secondary and tertiary sectors. That is, river regime changes should be linked to overall manpower and economic development.

- Increases in Crop Yields - At the present time, expansion of the physical infrastructure is proceeding without achieving consistent increases in crop yields due to a failure to implement and apply the most recent agricultural technology. To improve crop yields the following technological package is recommended:

Increased crop yields using proper irrigation techniques.

- Soil surveys at the present time are inadequate for determining suitable crops or the proper levels of water application for these crops. The soils need to be classified more adequately and more appropriate soil analyses should be used to determine water application needs. O.M.V.S. can assist in the compilation of these data and the provision of technical assistance to see that it is carried out.

- Soil analyses should be carried out as part of a master land use plan before any new perimeters are developed. Previous sections in this report have recommended that O.M.V.S. have responsibility for coordinating land use planning and specifying the data required for such planning.

- A coordinated research effort needs to be carried out under O.M.V.S. supervision to determine the best existing crop varieties for a particular area. The existing research centers are working primarily on development of new crop varieties and not on selection trials of existing varieties. It is felt that within these existing institutions, and with only minor training inputs, this program can be supervised by O.M.V.S. and results disseminated to the appropriate extension unit.

- Additional research efforts must be accelerated to determine fertilizer and water requirements for the crops identified with the given specific soil conditions. SAED has recently recommended the placement of agricultural extension agents at the irrigated perimeters to determine these requirements, but the agents are not yet in place.

- O.M.V.S. can assist the national irrigated perimeter agencies in these functions by developing a manual for performing these studies and training member state personnel in their

execution. The O.M.V.S. Directorate of Training and Promotion of Human Resources, with assistance from national and international experts, can use the skills of mass communications specialists in developing the actual guidelines.

- Remedy of Design Deficiencies and Operational Problems for Irrigation and Drainage Systems - A number of design specification and operational problems in irrigation and drainage systems have been specified in some detail, within the body of the Agricultural Development Partial Report.

  - The O.M.V.S. Hydro-agricultural Development Division can begin to develop and specify standards for irrigation and drainage systems within the limits of its present authority.

  - A preliminary evaluation study should be conducted to assess the condition of all canals in the existing irrigated perimeters throughout the Basin.

  - Design criteria should be established for improved irrigation and drainage systems. A system should be selected that will be more efficient and easier to operate than the existing systems. Design criteria should emphasize canal linings, elevated gravity feed channels, standardized pumping equipment, installation of water measuring devices and simplified operation procedures.

  - To assure the success of the above actions in the Delta Region, studies should be conducted of saline and sodic conditions in the root zone of crops from water table build-up, detailed soil and drainage mapping should be conducted as well as soil permeability studies to establish subsurface drainage design criteria.

- Maintenance of Irrigated Perimeters - Increased emphasis is needed on proper maintenance of all existing irrigation and drainage systems in both large and small perimeters. This includes canal clearance and pump maintenance. Intensified maintenance activities will require restructuring of the operations and maintenance divisions along the lines suggested for SAED in its maintenance program;

  - Attention must be given to proper land leveling and grading of parcels.
  - Water measuring devices must be installed to ensure the correct application of water.
  - Irrigation water management and operation units should be established or improved for each perimeter to ensure efficient water control.

- Agricultural Extension - Improved agricultural extension services in each O.M.V.S. Member State are needed to provide individual farmers with agricultural practices that promote high, year-to-year crop yields and management of natural resources affected by agricultural practices and grazing. The objective of these agricultural extension services is to provide farmers with training, information and guidance necessary for successful irrigated agriculture. An extension service's work with farmers has the following specific goals:

  - To improve irrigation efficiencies and cultivation practices,
  - To provide guidance for establishment of cropping patterns,
  - To provide effective measures for using fertilizers and pesticides,
  - To identify pest and crop diseases,
  - To guide cultivation practices to maintain a low reliance on chemical use,
  - To provide information about successful research techniques and agricultural practices in other portions of the developing world,
  - To provide a link between farmers and government activities associated with agricultural development.

Hence, organized, effective extension services are essential before large-scale agricultural development in the form of irrigated perimeters can begin.

- Reorganization of the Existing Extension Service - The existing structures of extension services in Mali, Mauritania and Senegal under OPI, SONADER and SAED, respectively, are recommended to be utilized with expansion and modification. Its organizational structure is summarized as follows (Benor, 1977):

  - The Village of Extension Worker - Extension efforts should begin by concentrating trained personnel on the task of improving agronomic practices that can be introduced immediately and that will result in rapid improvement of agricultural production with little financial risk. Each success generates more enthusiasm for further expansion of extension services, resulting in significant improvements in agricultural productivity. Approximately 10 percent of the farmers in each family group should be selected as contact farmers on which village workers can concentrate their efforts. These farmers can be chosen in consultations with village leaders and should be chosen so that their views are well respected by the remaining 90 percent of the farmers. The village extension worker should plan weekly visits with these selected farmers. Half of the day can be used for field visits, demonstrations and recommendations to review progress and ascertain technical difficulties farmers are experiencing. The other half day can be used for group discussion of these matters. The village extension workers should periodically report progress to support personnel, receive advice and additional knowledge and training, and prepare this newly imparted information for presentation to the farmers. Village extension workers should also have direct contact with subject matter specialists.

- The Agricultural Extension Officer - They should be responsible for initial and periodic training programs of approximately 8 village extension workers per agricultural extension officer, providing training sessions by subject matter specialists. They should also provide field supervision and assistance to village extension workers. These officers will report periodically to the subdivisional or district officer.

- The Subdivisional or District Officers - The subdivisional or district officers should be in overall charge of the extension program in their area. One of these officers can supervise six to eight agricultural extension officers. The subdivisional or district officers should spend more than half their working time performing field and training supervision activities. Each of these officers should be supported by subject matter specialists.

- The Subject Matter Specialists - Initially each officer should have at least one agronomy specialist, one plant protection specialist and one training specialist. Other subject matter specialists should be available in each O.M.V.S. Member State when problems arise in fields of:

    - farm management.
    - water management.
    - farm equipment.
    - animal husbandry.
    - agronomy.
    - fertilizers and insecticides.

  These subject matter specialists can be responsible for training sessions and field visits to assist other extension personnel as well as visits to research facilities and other

districts where specific problems arise. One specialist for every 120 to 160 village extension agents is a recommended ratio for determining the number of needed personnel.

- The Extension Service Headquarters - The extension service headquarters, established as a section of OPI, SONADER and SAED, should provide administrative services, development and modification of training programs, and monitoring of the extension service and its effectiveness. These three tasks should be coordinated by deputy directors in each O.M.V.S. Member State.

  Such an organizational structure must have an understandable line of authority with close supervision of all personnel. Strict adherence of village workers to advising and directing farmers is essential in order to avoid ineffective use of workers performing other services not related to agricultural guidance.

Human Environment-related Recommendations

- Resettlement - The most desirable mitigation of resettlement problems resulting from the development of irrigated perimeters would be an attempt to avoid resettling people. Irrigated perimeter development should be programmed where possible so that all cultivators have no more than a six kilometer walk to an irrigated site. In this way, cultivators will be compensated by an irrigated plot for their losses of flood recession land and resettlement will be avoided to the maximum extent possible.

- Displacement of Herders - Under present O.M.V.S. plans provisions are being made to devote 14.5 percent of land in irrigated perimeters to

forage production in both the wet season and the dry season (Groupement Manantali, 1977). By 2028, the irrigated perimeters are projected to produce enough feed to meet the needs of 93 percent of a cattle population the size of that estimated in the Senegal River Basin in 1976. Forage cultivation seems the best measure to mitigate the loss of recession land forage from the River's edge during the dry season. Cattle corridors across the perimeters will have to be established to bring the cattle to water. Piping water to specified sites or strategically located wells are an alternative with less risk of damage to the crops. Careful monitoring should be maintained at any man-made watering hole to assure that concentrations of cattle in these areas do not cause habitat deterioration, hastening desertification.

- Land Tenure - The irrigation land distribution system that will occur as the result of conversion from the current system of land use to irrigated agriculture could cause social tension. The share of irrigated land distributed to each family is critical to the stability of the family. Additionally, many noble families will object to foregoing their caste privileges in exchange for small plots. Nevertheless, any increases in plot size aimed at defusing this opposition must be accomplished on an equitable basis for all castes.

  The succession or inheritance of land must also be solved. O.M.V.S. should set up a committee to study the problem and give its opinion as to what alternative has the greatest probability of encouraging stability from generation to generation in the perimeters. One possible solution is for a tenant's successor(s) to inherit his right to cultivate. This would entail a periodic redistribution of the land to maintain equity among families.

- Integrating the Traditional Farmer into the Agricultural Development Program - A major psychological stress on the historically independent farmer will be his closer reliance on government in order to function.

The most important measure to mitigate the impact of the dependency complex of the tenant farmer is placing an initial priority on small perimeter development. Presently, most of the inhabitants of the Basin are engaged in subsistence agriculture. Subsistence farming involves fairly simple inputs, cultural techniques and knowledge that have been acquired through generations of practical experience. In the past, there has been a tendency to believe that the traditional farmer would resist change and would be difficult to train. This need not be the case if the right approach is used and if the necessary incentives and supports are provided.

Traditional method of storing corn in corn cribs.

The agency in charge of agricultural development in Senegal, SAED, has implemented a program for large and small irrigated perimeters in the Basin. SAED has learned from this experience that the participation of the villagers in developing the small perimeters has substentally decreased the development costs and increased the intended rate of return of these perimeters. In fact, one of the primary strategies of the O.M.V.S. development program is to set up small, village-level perimeters that can be used as training centers to assist the

subsistence farmers in making the transfer from traditional to irrigated agriculture.

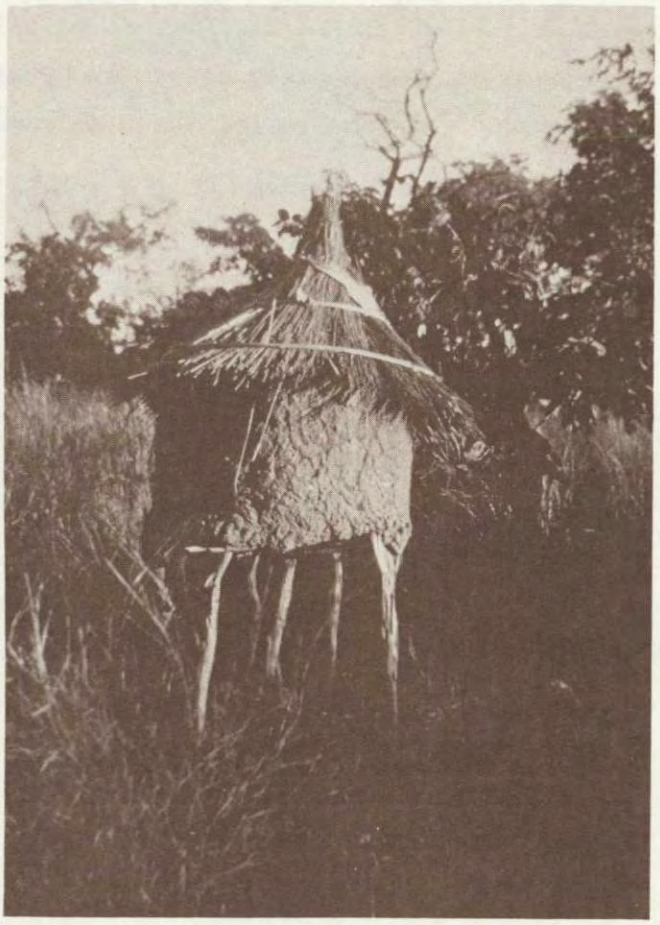
As the farmer becomes more responsible for building the irrigation works on these small perimeters, for the inputs to cultivation, for the field labors and for marketing the output, he will return to the current situation of self-reliance. He will thereby retain a certain degree of autonomy while still coordinating his activities with the government agency.

O.M.V.S. should establish a Permanent Irrigation Perimeter Surveillance Branch. The branch will need a chief of staff, a senior technician and a senior socioeconomist. It will also need twelve junior level field personnel. It should be possible to staff the office from nationals of the O.M.V.S. states. The junior staff members will visit each irrigation perimeter quarterly to monitor the organization of production, the technical lapses on production, the level of production itself, the net income of tenant families and the general morale of the men and women participating in irrigated agriculture. The junior staff members should also keep track of the rate of out-migration as an indicator of dissatisfaction with the operation of the perimeter. The senior staff should analyze the data of the junior staff and make recommendations to the appropriate authorities. The first task of the Permanent Irrigation Branch will involve a one year study to develop an Irrigation Master Plan for the Senegal River Basin.

- Short-Term Food Shortages Due To Conversion To Irrigated Agriculture

The most serious adverse impact of perimeter construction will be the elimination of land from cultivation during the irrigated perimeter construction period. The agency that is developing the perimeters can mitigate this impact by stockpiling food grains to feed the people who will temporarily loose access to their lands. The agency should have a stockpile of grain capable of replacing the grain harvest lost in

in a given year. A program should be developed by O.M.V.S. and the Member States to compensate for potential short falls in food supplies.



Traditional storage of grain. Such methods are inefficient for large-scale storage.

Public Health-related Actions

Health Education is considered a practicable and effective measure that can be achieved by the services of a primary health care program. This program, which will concentrate on preventive health measures, provides the necessary structure for this purpose by establishing a Health Monitoring Group within the O.M.V.S.

- Malaria. Increased malaria vector mosquito breeding is primarily related to flooded rice paddies. To eliminate these would require

changing to an overhead sprinkler irrigation system. The cost and extensive maintenance requirements of such a system places it beyond consideration, unless it can be justified on the basis of agricultural productivity. The development of a primary health care system is recommended as the most suitable and cost-effective mitigating measure for dealing with the problem of malaria.

- Shistosomiasis. Because of the possibility that the intermediate snail vector, Biomphalaria pfeifferi, may eventually colonize the canal systems of irrigated rice perimeters, in theory there would be merit in either excluding from the Basin those individuals infected with S. mansoni, or treating them. Except for specific situations, this would be extremely difficult, if not impossible to achieve. Snail Vector Control will probably not be necessary in irrigated perimeters under 100 hectares. For more extensive rice perimeters with double cropping, an increase in vector snail populations is a possibility. Whether this will result in increased transmission of schistosomiasis is unclear. Nevertheless, certain practices considered essential for cost-effective and more productive irrigation systems are also helpful in reducing populations of vector snails. These include:

  - Use of appropriate materials for canal construction,
  - Careful maintenance of canal dikes to avoid seepage,
  - Installation of silt trap at the water intake and manual removal of silt in irrigation canals to minimize intrusion by aquatic plants,
  - Control of aquatic plants to reduce snail habitat,
  - Lining canals with concrete or plastic sheeting or the use of covered water canals (closed) will eliminate or reduce vector snail breeding. However, for reasons of cost-effectiveness, this is not recommended for snail control alone.

The O.M.V.S., in close collaboration with the national irrigation authorities, must develop a master plan for the development of irrigated agriculture throughout the Senegal River Basin. The master plan should project development activities over the next fifty years. It should generate minimum social, economic, public health and technical standards for the perimeters.

Natural Environment-related Recommendations

- Control of Crop Diseases and Pests - Unless certain crop diseases and pests are controlled, productivity of the major food crops will remain submarginal. Although no crop protection programs exist in the Senegal River Basin, the USAID sponsored Sahel Food Crop Protection Project (SFCPP) is now in the process of implementing crop protection services in the O.M.V.S. Member States. Coordination of this program by O.M.V.S. is vital.

  Additionally, a well organized, viable extension service by SAED, SONADER and OPI can assist farmers in identifying specific pests, and in selecting and applying the proper pesticides.

  - Control of Nematodes will require additional services including laboratory analyses of soil samples to identify the species of nematode, determination of the size of the population and proper choice and application of the nematacide.

  - Harvesting rice in September while the Quelea are breeding in remote savannah areas, use of the chemical methiocarb on sprouting rice to control ruff and tree-duck predation, physical removal of nesting colonies of weaverbirds near rice field, should maximize production of grain crops.

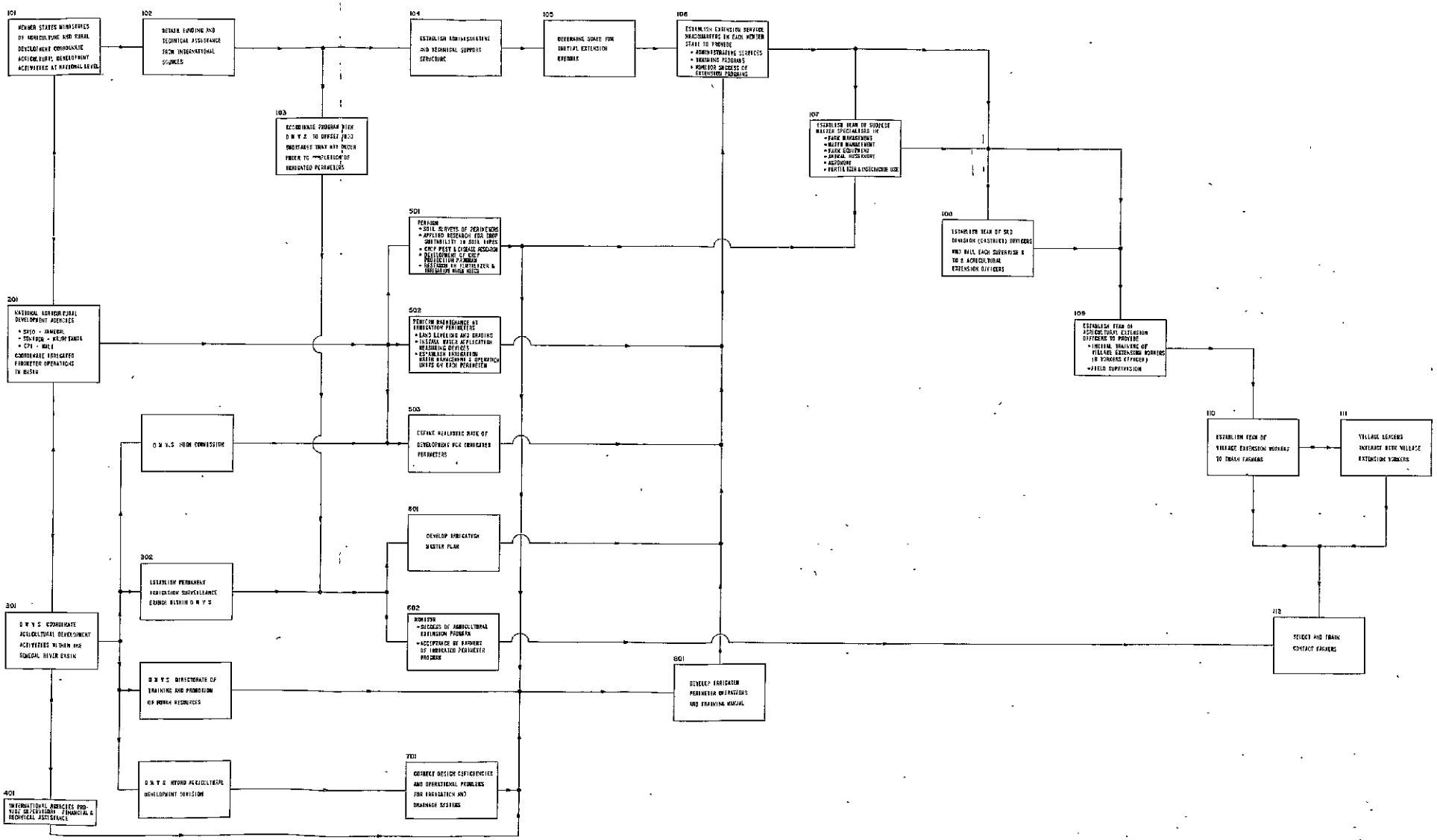
  - Rodents, a serious pest in the Basin, can be controlled by destruction or reduction of habitat, and poison bait programs. This program should be an activity of the extension services in the O.M.V.S. Member States.

- Protection of Forests and Wildlife Habitat - As part of the Master Land and Water Use Plans recommended by this Study, a coordinated effort by O.M.V.S. and its respective national agencies should plan location of future agricultural perimeters around major forest habitats. The protection of these forests and the expansion of the existing park network will greatly benefit wildlife in the Basin. In conjunction with agricultural development, it is recommended that O.M.V.S. and the respective national ministries establish a mosaic of wildlife preserves along the Senegal River.

- Development of an Integrated Agriculture/Fish Culture Program - Details are provided under the Diama dam discussion.

- Develop a Program for Handling and Storage of Pesticides - This can be integrated into the Agricultural Extension Program.

Properly implemented, integrated water and land use planning in the Basin can turn this Sahelian Region into a green belt. (Richard Toll Sugar Plantation).



AGRICULTURAL DEVELOPMENT PLAN OF ACTION

FIGURE 22

PROGRAMMATION DES ACTIVITES CONCERNANT LE DEVELOPPEMENT AGRICOLE DANS LE BASSIN DU FLEUVE SENEGAL

PROGRAM SCHEDULING ASSOCIATED WITH AGRICULTURAL DEVELOPMENT IN THE SENEGAL RIVER BASIN

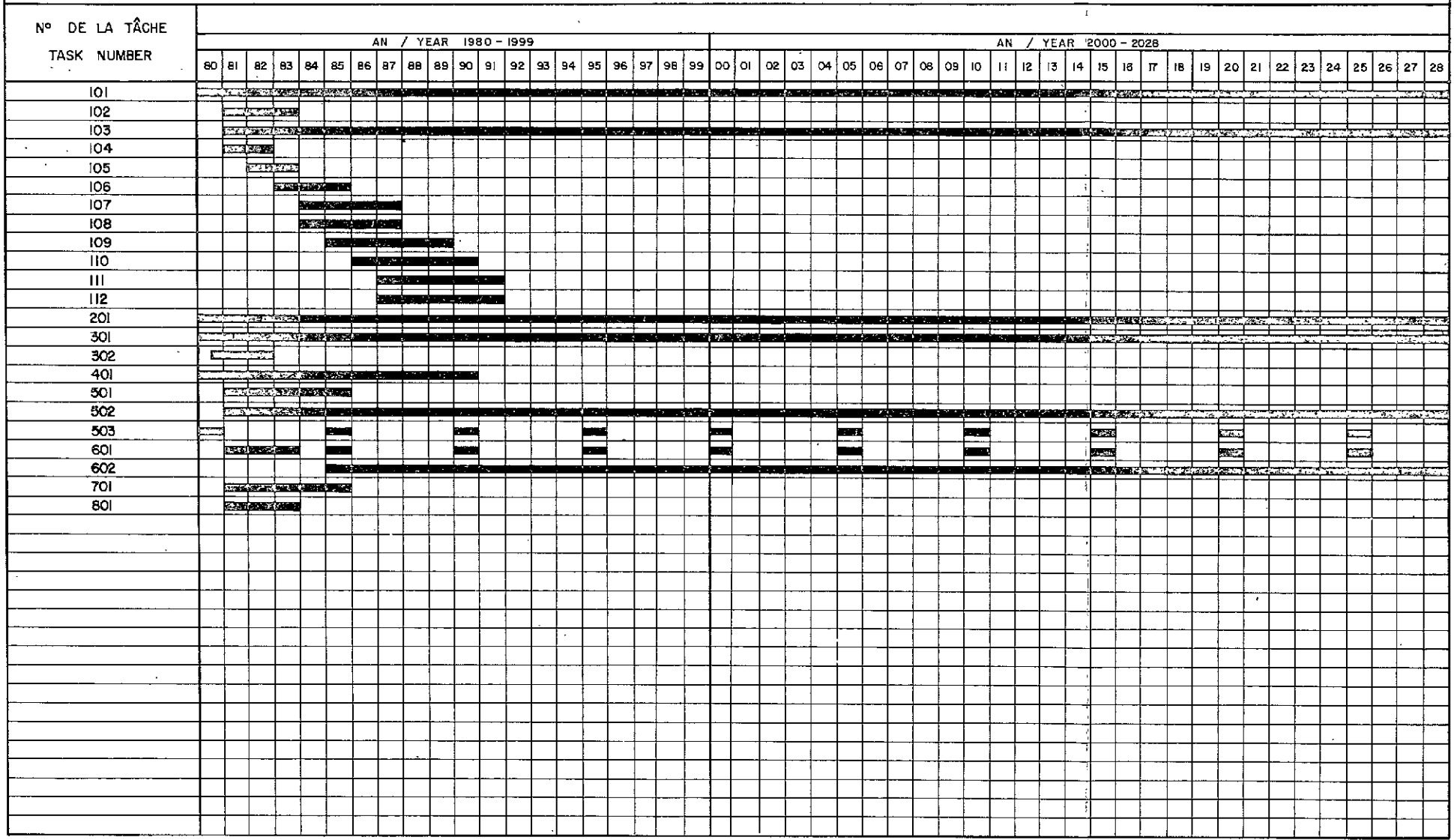


FIGURE 23